NATURE

No. 4405 SATURDAY, APRIL 3, 1954 Vol. 173

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THE INDEPENDENT RESEARCH INSTITUTION

THE major and wider interest of Dr. Vannevar Bush's report for 1952–53 as president of the Carnegie Institution of Washington lies in his review of the position and opportunities of the privately endowed research institution to-day, particularly in view of the concern so freely expressed in the United States and elsewhere as to the growing dependence of fundamental research on government support. Dr. Bush begins his report with an appreciation of the particular opportunities of the Carnegie Institution itself, before turning to discuss the position of the independent research institution in general. His observations are an important contribution to a discussion which was provoked afresh by the analysis of government expenditure on research in the United States carried out by the National Science Foundation, and they have a close bearing on the future activities of such bodies in Great Britain as the Nuffield Foundation and the Carnegie United Kingdom Trust.

Dr. Bush is impressed by the opportunities which confront the Carnegie Institution, provided national conditions permit it to operate effectively. He sees the Institution's work on the genetics of lower organisms and the earlier phases of life processes as fundamental to the future use by man of lower organisms for food production, to separation of raw materials from the sea and the synthesis of complex organic compounds for industry or for physical welfare: "There is evident opportunity for another fifty years of exacting endeavour in elaborating a constantly widening set of concepts". So, too, he believes that out of the Institution's studies of the ionosphere, of terrestrial magnetism and of geophysics, may come improved communications, new sources of materials and a fuller understanding of man and his environment.

Turning to the general position, Dr. Bush points out that the view that the day of the independent research institution is ended and that in future fundamental research belongs to the universities with heavy subsidies from government implies two criticisms. First, it implies that the research institution is isolated and that the interchange and cross-fertilization of a university community is essential now that disciplines are becoming more intimately interlinked. Second, it implies that fundamental research and the education of brilliant students should be closely related, and that the research institution is prone to ingrowth and stagnation in the absence of the continued impact of young minds.

Dr. Bush admits that these are cogent points of which the research institution must take account. He does not admit, however, that the criticism is necessarily valid. These are dangers to be watched rather than reasons for abandoning the research institution. Isolation is a matter of attitude rather than of geography, and it can characterize a university department as well as an independent institution. A research department far from universities may

become a national or even a world intellectual centre in its field, where those intimate interchanges between masters occur which are often the seeds of progress. Dr. Bush's remarks bear pertinently on the question of academic interchange and the wisdom of doing all that is possible to foster schemes for academic interchange now being operated.

Nor is formal education, which is not the business of the research institution, the only means of contact with youth. Dr. Bush maintains that if a research institution allows itself to become old in its ways the fault is its own, and especially, he suggests, in its methods of selecting and treating its staff. If it is careful to expose itself constantly to the influence of young minds, to select its recruits not simply for their mental ability but also for their capacity to blend into a scientific community, and if its younger members are at once given the opportunity of participating effectively in its programmes, its group discussions and plans, the research institution will go far towards maintaining its vigour and avoiding the danger of rigidity and narrowness to which a community of scientists alone is liable.

This problem is inherent in all research organizations, and Dr. Bush is emphasizing much that was well put in the Barlow report on scientific staff ten years ago. His essential point is that the research institution is quite as well able to create the conditions which will attract outstanding men and give full play to their creative ability as any other form of research organization; and apart from this, he believes that the independent institution has advantages which more than offset any dangers of rigidity or ossification. Outstanding achievement in fundamental research is above all a matter of locating the individual of genius and supporting him liberally as he pursues his own way. Dr. Bush's philosophy is fully in line with that expounded by Mr. Raymond B. Fosdick on behalf of the Rockefeller Foundation and Mr. Chester I. Barnard for the National Science Foundation.

It is, however, not to the utterly lone genius, incapable of working with others, that scientific advance owes everything; we must also consider those whose brilliant creative skill is combined with the human attributes that make them welcome in a community of their peers, so that their full creative contribution is seen not merely in their own direct results but also in terms of men as well. Dr. Bush believes that the independent research institution, free from the distractions of teaching, is even better placed than a university department to provide the climate in which such individuals can function to the best of advantage. He believes also that the research institution, with its tightly knit groups, is also better equipped than the university department for locating genius before it has matured and established a reputation. Young men of promise are best picked by men in the same field, subject to checks first by senior colleagues, and then, as in the Carnegie Institution of Washington, by such officers as the president and trustees, who are concerned to see that high standards are maintained and due diligence emphasized in the quest for talent.

A new young scientist of great creative ability is best developed, in Dr. Bush's opinion, by incorporation in a group consisting largely of men of that character, whose selection of novices, rotation and further selection is under the leadership of a scientist possessing the sound judgment in the selection of men which is a primary attribute of a successful director of research.

All this can, of course, be done in a university department, though so far as fundamental research is concerned, Dr. Bush thinks, less successfully. These are his reasons for believing that, provided the research institution is adequately endowed, fundamental research can be carried on more fruitfully in it than anywhere else; and on this question of endowment Dr. Bush is highly critical of recent trends in the finance of research in the United States. He points out that the sponsoring of fundamental research by the Government has not hitherto increased significantly the volume of fundamental research. More important, it has not, by sponsoring, created new centres of research or secured the permanent expansion of existing centres. Moreover, the great foundations have turned away from endowment grants and distributed their funds mainly on a project basis.

Although this distribution, as is clear from such reports as those of the Rockefeller Foundation and the Nuffield Foundation, has been directed largely towards what are, in the judgment of their trustees, the growing points, in accordance with the view for which Lord Beveridge argued so cogently in his report on "Voluntary Action", Dr. Bush believes that, by keeping the selection of actual projects in their own hands, the Foundations have hindered the full expansion of fundamental research. He believes they have missed an opportunity. When the Government began to increase strongly its support of scientific research, they should have maintained the balance by increasing their own support of fundamental research, and particularly by creating and endowing new independent institutions where it was most likely to prosper.

Dr. Bush admits that something has been done; but he maintains nevertheless that the scope for fundamental research has expanded far more than the means for its furtherance. In general, independent foundations have not tackled the problem of extending fundamental scientific research in the United States, nor is there any great indication that they will do so.

So far as the United States are concerned, Dr. Bush's remarks have to be considered in the light of the opinion freely expressed in that country that the level of fundamental research is far below what is required to enable it to make contributions to the advancement of science, as distinct from technology, commensurate with its greater resources. The National Science Foundation's recent inquiry showed that in 1951–52 the total funds available to non-profit institutions for research and development were 338 million dollars, compared with the Federal Government's appropriation of 2,217 million dollars; and although the latter figure is estimated at 2,074 million dollars for the fiscal year 1953–54, the

resources of non-profit institutions are unlikely to exceed the previous 15 per cent of the Federal funds available for research and development. Moreover, from the latter funds expenditure on fundamental research is of the order of 120 million dollars, or some six per cent of the total, and this expenditure tends to increase less proportionately than that on applied research and development. Further, of the funds going to non-profit institutions, only about 20 per cent was for basic research, the remainder being for applied research and development. Even in medical research there has been a similar trend, Federal funds providing a major source of support—roughly 76 million dollars out of 181 million dollars in 1951, compared with 60 million dollars from industry. The Commission on Financing Higher Education in the United States estimates that out of 222 million dollars expended by higher education institutions on organized research in 1950, about 60 per cent was on contract research for the Federal Government.

American opinion is thus disturbed, both that this large Federal contribution is not big enough for the amount of fundamental research that is desirable, and that it represents too high a proportion of the funds available for the research institutions. This latter concern is increased because, as the Commission on Financing Higher Education in the United States suggests, much of the Federal support goes for purposes ill-related to those which the research institution is primarily concerned to further. Apart from the danger of distortion inherent in this position, concern has been expressed, for example, by Mr. R. D. Reid, of the Office of Naval Research, that the effects on individual freedom and initiative may be adverse. Although the Office of Naval Research seeks to administer its research programmes and funds so as to stimulate creative work and the increase of fundamental knowledge, Mr. Reid views the trend towards Federal support with uneasiness. He distrusts reliance for funds upon any single agency, even the National Science Foundation, for support of basic research even in the medical sciences. Finance is not the sole or even the most important requirement, and several agencies, with their differing points of view, their various needs and different groups of advisers, offer a greater safeguard against uniformity, and assurance that due consideration will be given to research projects in entirely new fields—to the potential growing points—of which bodies such as the Rockefeller and Nuffield Foundations and the Carnegie Institution are rightly mindful.

The Office of Naval Research carries responsibilities which in Great Britain largely fall on the Department of Scientific and Industrial Research or the Medical Research Council, and this warning as to the limitations of administration deserves to be noted. Moreover, while accepting the necessity of group research or team-work, Mr. Reid reminds us that the important discoveries are usually the result of the intellectual adventures of talented individuals, and his comment that in his personal experience some enforced frugality has stimulated productivity is parallel to an observation of Sir Ernest Barker in his recent book. Sir Ernest wonders whether we do not think too much about equipment and accommodation. They matter, but perhaps not as much as we think. Sir Ernest's experience that poor accommodation is often a spur to good education is, of course, not a justification for ill-equipped laboratories, but endorsement of the truth of Rutherford's remark: "We haven't any money; we've got to think".

Still more recently, President H. W. Dodds, of Princeton University, has discussed the dangers and limitations of project research in a statement on university research policy published in the *American Scientist* (**42**, 128; 1954). President Dodds recognizes that the team-work usually demanded in sponsored research when it is good can make for cross-fertilization and mental stimulation, while the external discipline laid upon the leader and his team to see that the trust is honoured is also an advantage. None the less, there is a danger of diminishing returns, and like Mr. Reid, Dr. Dodds notes the danger of decreasing self-reliance and of over-planning and regimentation. A university, he insists, must never, in accepting projects, swerve from its obligation to advance fundamental knowledge, but above all Dr. Dodds is concerned that the imposition of secrecy in connexion with sponsored projects contravenes the prompt and free pooling of knowledge by which all science advances.

Any barrier to the free trade in ideas throttles the process of discovery, and Dr. Dodds suggests that three principles should determine the acceptance of any sponsored research project by a university. The sponsored undertaking should be related to the fundamental long-range programmes of the faculty concerned. Second, the undertaking must not interfere with the university's duty to maintain and improve its own resources and facilities for the support of its own programmes; and third, the university must exercise the same diligence and wisdom in the utilization of its own resources as it does in respect of grants which it accepts from outside for sponsored research.

Apart, however, from the dangers which may beset the research institution if it does not exercise great discrimination in the acceptance of sponsored projects, there is a further difficulty, to which Dr. C. P. Richter has directed attention in an article, "Free Research versus Design Research" (*Science*, **112**, 91; 1953). Dr. Bush in his report to the trustees of the Carnegie Institution recognizes the importance of the Institution retaining the power to select its own projects in the light of the collective wisdom of the research group. Mr. Richter hammers home the point that unless the individual has reasonable freedom, we do not get the best out of him. Funds for research, he argues convincingly, should be given with as few strings attached as possible. Experimental design should not be mistaken for ideas, and it is the man rather than the project who should be backed, at least so far as fundamental research is concerned. These points are just as applicable in Great Britain as in the United States, and those concerned with the allocation of funds for research should always have them in mind.

ATOMIC ENERGY IN GREAT BRITAIN AND THE UNITED STATES

Britain's Atomic Factories

The Story of Atomic Energy Production in Britain. By K. E. B. Jay. Pp. ix+100+16 plates. (London: H.M. Stationery Office, 1954.) 5*s*. net.

Report on the Atom

What You Should Know About Atomic Energy. By Gordon Dean. Pp. 288+16 plates. (London: Eyre and Spottiswoode (Publishers), Ltd., 1954.) 16*s*. net.

THE nearly simultaneous appearance of these two books on the subject of atomic energy is in a sense a real landmark in the history of the subject. Both are written with inside knowledge of the spectacular developments made in recent years in this rapidly growing field. One is concerned with British progress and the other with American. The report by Mr. K. E. B. Jay is more restricted in its scope and, indeed, he does not stray far from the chosen subject of factories at any time. On the other hand, Mr. Gordon Dean gives his attention to nearly all the questions that are involved in any comprehensive study of the atomic energy programme, including the use of weapons. Yet the aims of the authors are very similar. Throughout they are anxious to explain the methods of the responsible bodies, the Ministry of Supply in Britain and the United States Atomic Energy Commission, and they perform their tasks with clarity and as much detail as necessary.

Both writers achieve an unusually high standard of lucidity in expounding what is largely a complicated scientific and technological subject. There is some little suggestion of the expert turned reporter in Mr. Jay's work and what one might call the reverse in Mr. Dean's. But the degree of success is such as to leave one with a feeling of regret that such instances do not occur more frequently. It is obvious that a law training is not lost in scientific fields.

The bulk of each book is concerned with a highly complex scientific and engineering project, and in spite of their notable success it is still true to say that the educated layman will find much that is difficult to digest. All the material is interesting and even stimulating to the careful reader; but the books are meant for serious study, and application is essential to extract anything like their full value. Mr. Jay's account shows clearly a desire to provide the scientific basis for the various processes described, but he is wise in providing the exposition of the underlying physical principles in the form of an appendix. This allows him to proceed without seriously overloading the average reader at any point. Mr. Dean succeeds very admirably in this same respect by virtue of his ready ability to draw neat analogies from more familiar fields of experience.

The specialist will find a great deal to interest him in these books. The comprehensive sweep of the authors over fields involving physics, chemistry and engineering serves to clarify the principal trends in the whole project. In spite of unprecedentedly firm control of publication, there has been a great number of papers from the various laboratories involved, and these books help in relating many of these specialized publications. Both books start with prospecting for ore and go as far as the pile for energy production or the door of the weapons factory. Mr. Dean sidesteps actual weapon production; but he has many interesting and timely points to discuss concerning tests, stockpiling, strategy and other related topics. Regarding tests, many scientists will envy electricians who can earn 800 dollars a week, even if the circumstances are exceptional. In addition to handling weapons, Mr. Dean considers security and the Russian effort; here he shows a reasonable middle-of-the-road approach which will be favoured by many and which can provoke very few.

In one respect both writers, through no fault of their own, leave the reviewer rather unhappy. Much of their effort is expended in demonstrating how well both programmes have been handled. This appears to be a rather barren effort as there are no standards of comparison, or very few, in this field. Both are national efforts, and security prohibits any estimate of the cost of an atom bomb or even an ounce of plutonium, say. It is somewhat like the situation when the management insists that it has cleverly handled affairs, but nevertheless refuses to give any financial statement on the operation. It is difficult for the shareholders to join the eulogy no matter how sympathetic they feel towards the claims of the personnel. Apart from this question of what might be termed efficiency, there is left with the reader a very real sense of difficulty in estimating how long it will be before piles supply useful energy on a commercial basis.

There is a compactness and neatness in the British programme as described which contrasts rather strongly with the apparently more haphazard and empirical approach in the United States. Yet somehow one is impressed with the feeling that the latter method would probably achieve real results very quickly if it was directed mainly along the line of peaceful applications. The main contrast, indeed, in the two countries is not in technological matters, although differences do appear here (as, for example, in the processing of ores), but rather in its organization. The American scheme of awarding contracts to industrial companies, mostly of major standing, on a cost plus nominal fee basis does not have a real counterpart in Britain. Although many well-based objections can be made to the American system, and these are fully and frankly voiced by Mr. Dean, one is yet aware of the enormous benefits that can accrue when it proves successful. One feels that the more tightly governed British effort could result in a severe handicapping of the major firms in the international race towards successful tackling of the many original scientific and technological problems created in the widespread application of atomic energy in a peace-time economy. Names such as Du Pont, General Electric, Westinghouse and Union Carbide and Carbon appear throughout the American report, and in several instances the whole problem is left to these concerns. The difficulty of ensuring that full use is made of the nation's skill is aggravated by the fact that the British effort was delayed by the transfer of the whole of the British personnel to the United States during the War. Thus the American manufacturer had a big start in the new field, and his progress in the construction of ship reactors (submarine) is perhaps an especially noteworthy example of this.

The above is merely one of the many issues that will occur to the thoughtful reader of these two authoritative and excellent accounts of the work in atomic energy. All non-specialists are indebted to

each of the writers for bringing under one cover so much of a subject which is of vital concern to all. Both books can be very highly recommended. They are in no sense in competition with each other—they are, in fact, complementary. They are excellently produced and cheap for books of their type. It is unfortunate that Mr. Jay's work is not produced with a more durable cover. S. C. CURRAN

PHILOSOPHICAL ANALYSIS OF 'OBJECTIVE' PROBABILITY IN SCIENCE

Scientific Explanation

A Study of the Function of Theory, Probability and Law in Science. By Richard Bevan Braithwaite. (Based upon the Tarner Lectures, 1946.) Pp. xii + 376. (Cambridge: At the University Press, 1953.) 40s. net.

THE eleven chapters of this book are intended to examine (or re-examine ?) the logical features of all sciences. The term 'science' is understood to mean a hierarchical deductive system in which the lowest-level generalizations from the observed facts are deduced from more-general higher-level hypotheses. This very general level of discussion is maintained in Chapters 1–4 (introduction; scientific deductive systems and their representations; the status of theoretical terms in science; models for scientific theories, their use and misuse). Also, the same general tone is characteristic of the last four chapters (the justification of induction; laws of Nature and causality; causal and teleological explanation; explanation of scientific laws). The middle of the book, composed of three chapters (statistical hypotheses, probability statements and class-ratio arithmetic; the meaning of probability statements within a scientific system; the choice between statistical hypotheses), is much more specific than the rest and deals with the gnoseological questions related to modern theories of probability and statistics and, more particularly, to the applications of these disciplines in experimental sciences.

In his preface Mr. R. B. Braithwaite states that, "if I were asked what there is that is original in this book, I should mention specifically the accounts of probability as used within a science (Chapters V and VI) of the relation between scientific theories and 'models' of them (Chapter IV), and of teleological explanation (Chapter X)". With respect to the other parts of the book, the originality of the author is limited to exposition. No doubt, because of my personal inclination, the most interesting parts of the book appear to be Chapters 5–7, which are given to probability and statistics. Since the appearance of J. M. Keynes's "Treatise on Probability" (1921) and through the writings of Sir Harold Jeffreys, the philosophical literature on probability has mostly been based on the view that the term probability reflects in some way the intensity of belief of an individual in a given proposition. For this reason, the particular theories are sometimes called 'subjective' theories of probability. On the other hand, beginning roughly with the last years of the nineteenth century (Karl Pearson), a tremendous amount of work has been done on the development of the mathematical machinery and on its applications to the various branches of empirical science in which an essential part is played by relative frequency. This 'relative frequency' is attached to the appearance of various 'events' in repeated 'trials' either going on by themselves or performed by man. The idealized relative frequency became labelled with the same term 'probability'. Since the assertion that probability (understood as an idealized relative frequency) of a given event has a specified value p may be verified experimentally, the relevant theory is sometimes called the 'objective' theory of probability.

Perhaps because of the enormous field of applications (physics, astronomy, biology in general and heredity in particular, social sciences and experimentation) that kept the scholars busy with immediate specific problems, the existing philosophical literature concerned with 'objective' probability appears to be much less rich than that dealing with the 'subjective' probability. The honour of initiating the philosophical study of objective probability seems to belong to R. von Mises ("Wahrscheinlichkeit, Statistic und Wahrheit", Vienna, 1928). To my knowledge, the present book represents the next (after von Mises) serious effort to analyse the position and the meaning of objective probability in the body of modern science.

While the author's attitude towards probability in science seems to coincide with that of von Mises, there are very considerable differences in the developments. First, Mr. Braithwaite refuses to adopt von Mises's definition of probability as the limit of relative frequency. The definition adopted, based on the so-called 'class ratios', is essentially the same as the now classical definition of Kolmogoroff. (Here, however, somewhat to my surprise, the author is reluctant to deal with infinite sets and measure.) Furthermore, at the time when von Mises wrote his book the basic concepts of the modern statistical theory were much less clear than they are now, and this is reflected in von Mises's writings. Mr. Braithwaite has benefited from his proximity to the Cambridge Statistical Laboratory and, with the acknowledged co-operation of F. J. Anscombe, has mastered the young mathematical discipline. As a result, his book appears to contain the first presentation of the principles of mathematical statistics intended for a non-technical reader. This presentation is concise and at the same time quite inclusive, from the theory of testing statistical hypotheses, through estimation, to the general theory of statistical decision functions. Also, and this is quite an achievement, Mr. Braithwaite's presentation of the theory is devoid of the various misty mysticisms so frequently encountered in the many not quite technical books written by statisticians. In fact, they (the statisticians) will do well to read Mr. Braithwaite's book. Some of them will probably disagree with him on a number of points, but the process of disagreeing will be instructive. In general, the book is likely to be interesting to everyone anxious to attain a unified outlook on science.

One bibliographical remark seems in order. The concept of loss function, $L(h_1, h_2)$, that represents the financial loss to the statistician who accepts the hypothesis h_1 when, in fact, an alternative hypothesis h_2 happens to be true, is frequently attributed to Wald. There is some justification for this because in modern times Wald was the first to make extensive use of this concept, combining it with the 'minimax' idea. However, it is interesting that the loss function appears in the writings of Laplace in the form of

'detriment' that one will suffer when using an estimate $\hat{\theta}$ of a parameter the true value of which is θ. Laplace chose a particular form of the function to represent the 'detriment', namely, $|\hat{\theta} - \theta|$. Later on, the same problem was considered by Gauss, who noticed that much simplicity is gained by assuming the alternative form of the detriment $L(\hat{\theta}, \theta) = (\hat{\theta} - \theta)^2$. Incidentally, the adoption of this form of loss function initiated the theory of least squares and caused the contemporary preoccupation with the mean square error of an estimate, which is exactly the expectation of the detriment. In more modern times, the concept of the loss function or of detriment appears frequently in the writings of F. J. Edgeworth, but then, for some reason, became entirely forgotten. In 1933 the concept was rediscovered by E. S. Pearson and myself (*Proc. Camb. Phil. Soc.*, **29**; 1933), and combined with the notion of what is now known as the minimax policy. However, after formulating the idea, we did nothing with it. The next rediscovery of the idea was due to Wald, who used it to the fullest extent and on it built his remarkable general theory of statistical decision functions. JERZY NEYMAN

HIGH-SPEED FLUID FLOW

Modern Developments in Fluid Dynamics

High Speed Flow. Composed under the ægis of the Fluid Motion Sub-Committee of the Aeronautical Research Council. Edited by L. Howarth, with the assistance of H. B. Squire and the late C. N. H. Lock. (The Oxford Engineering Science Series.) Vol. 1: pp. xvi+476+9 plates. Vol. 2: pp. viii+400+17 plates. (Oxford: Clarendon Press; London: Oxford University Press, 1953.) 84*s*. net the set.

THE publication of these two volumes on aerodynamic phenomena as affected by the compressibility of the air will satisfy a long-felt want by many workers in the aeronautical field. Like their predecessors, these volumes appear under the ægis of the Fluid Motion Sub-Committee of the Aeronautical Research Council, but the editor is Prof. L. Howarth in place of Prof. S. Goldstein, to whom the work is dedicated.

The original volumes dealt only with the problems of fluid dynamics at speeds sufficiently low for the density of the fluid to be considered a constant. The very rapid progress of flight into transonic and supersonic regions has produced a great demand for aerodynamic data at such high speeds, where the effects of variations of density, viscosity and temperature can no longer be neglected and indeed play a dominant part in determining the nature of the flow. These two volumes set out to supply this need as far as is possible at the present time when many of the problems involved are far from completely solved. The editor and his collaborators are to be congratulated on the production of a fine work, especially as they must have felt themselves greatly hampered by the lack, in very many cases, of sufficiently extensive experimental data to enable them to assess the validity of approximations necessarily made in the theoretical treatment of the subject.

It can truly be said that in this field theory has outstripped experiment and that the great need of the moment is a systematic body of experimental data such as has been amassed during the past thirty years or so for the case of low-speed flight. There are two reasons for this lack: in the first place, problems of high-speed flight have been under intensive consideration for a comparatively short time; and in the second place, the equipment needed for their adequate experimental study is much more elaborate and expensive than that which sufficed for low-speed problems.

Dealing first with the theoretical side, which is the special province of the first volume, the field of investigation divides itself roughly into two parts. There is first the range of speeds from that at which compressibility begins to matter to that of sound, and this range is particularly difficult from the theoretical point of view when the field of flow comprises both subsonic and supersonic velocities and is characterized by shock waves of limited extent springing from the surface of the body considered. Secondly, there is the true supersonic range in which velocities are everywhere supersonic, so that the mathematician is no longer confronted by equations of both elliptic and hyperbolic type in the same field of flow. There are not yet, in fact, any complete analytical solutions of flow problems in which limited shock waves exist, but only in the cases where the speed is below that at which shock waves form or above that at which the flow is completely supersonic. Nevertheless, it is possible to throw some light on the intervening region by approximate methods.

After a general introduction and description of high-speed flow, the equations of flow in gases are elaborated, and in succeeding chapters the implications of these laws of flow are traced. The method of characteristics is described, and the properties of shock and blast waves examined. The hodograph method is treated at some length, and there is an interesting chapter on approximate methods, some of which have been of great use, despite their limitations, in giving the aeronautical engineer a basis for supersonic design. Problems of unsteady flow are next considered and complete the review of theoretical methods as applied to flow in an inviscid fluid. The last chapter, on boundary layers, shows how the methods previously developed for incompressible flow have been extended to the compressible case, and also contains some account of the interaction of shock waves and boundary layers, a subject as yet far from being completely understood.

The second volume, apart from its last chapter, deals mainly with the experimental study of high-speed flow. An account is given of the apparatus and methods that have been devised for such research, including force measurements, determination of pressure distribution, and visualization of flow by shadowgraph, schlieren and interferometer methods. Two chapters follow in which some of the available results are given on aerofoils and cylinders, and on bodies of revolution, illustrated by numerous diagrams and some excellent flow photographs. The discussion on bodies of revolution is confined mainly to spin-stabilized projectiles, and it is pointed out, quite rightly, that the study of projectiles took workers into the supersonic field even before flight was regarded as a serious possibility. It is an interesting thought that two apparently widely separated investigations, external ballistics and the aerodynamics of flight, have now merged together, and each can help the other in no small measure. The last chapter of the second volume deals with the

problem of heat transfer at high speeds. This is a matter of very great importance, and one that will become even more important as flight speeds increase, for it seems likely that the ultimate speed of man-carrying aircraft will be set by the thermal problems involved. Theoretical methods of dealing with heat transfer are considered, and their predictions, compared with experimental results, indicate that knowledge is in a fairly satisfactory state, considering the complexity of the problem.

The present volumes, like their predecessors, are provided with very copious references to other work on the subjects discussed. Recent progress in the theoretical and experimental study of high-speed fluid dynamics has been very extensive indeed, because of its obvious and vital importance in the development of air defence, and it is quite impossible to treat more than the broad outlines of the subject even in two fairly large volumes. The reader who wishes to look more closely into any particular part of the subject will find the references of great value.

While much of the theoretical matter is fundamental and will stand permanently, there seems little doubt that the present intensive experimental programme, in Britain and elsewhere, will very soon enable the subject to be treated far more fully. For the moment, the present volumes form probably the most complete account of the subject yet published.

ERNEST F. RELF

MASS SPECTROMETRY

Modern Mass Spectrometry

By Dr. G. P. Barnard. (Physics in Industry Series.) Pp. 326. (London: Institute of Physics, 1953.) 50s.

MANY still think of the mass spectrometer as a highly academic instrument, details of which have to be remembered only long enough to pass examinations in physics, whereas, as Dr. G. P. Barnard's book shows, it is now a powerful tool which has successfully invaded the world of industrial and biological research. The last five chapters of the book are, in fact, devoted to a discussion of some of the problems tackled by mass spectrometers. The longest of these chapters concerns only one application—the analysis of hydrocarbon mixtures; and here the actual position is well reflected, for it is in the oil-refining industry that mass spectrometers are now most used. The following chapter is devoted to applications in chemistry; and another is concerned with the use of mass spectrometers in biology. The latter contains also much useful material of a general nature on the techniques peculiar to stable-isotope tracer work with deuterium, carbon-13, nitrogen-15 and oxygen-18 respectively. Other shorter chapters are concerned with geology, physics, nuclear chemistry and engineering.

It should not be thought, however, that the mass spectrometer is not itself discussed in detail, for more than half the book is devoted to its general theory and design. Dr. Barnard's work on gaseous ion sources and their errors is well known, and his chapter on ion sources should therefore be approached with some respect. The space allotted to sources suitable for solid samples, however, is small; largely, of course, because little work has been published about them. This is regrettable, for in spite of their inconveniences and inefficiency the use of a source of this type could often, one feels, short-circuit a routine chemical operation involving small quantities of gas—always a laborious affair.

It is in those sections of the book dealing with more fundamental matters that a few obscurities appear. Thus, in the section dealing with circular motion of a charged particle in a uniform magnetic field, we find the statement "there is no linear acceleration but a constant angular acceleration". Again, electrostatic units are used here, but later, without warning, a formula appears which is based on Gaussian units; and on p. 73 we read of the "normal to a point". Such minor matters, however, are few in number and do not detract appreciably from the value of the book as a whole.

One cannot conclude a review of this book without mentioning the very full list of references, containing nearly five hundred entries—a most useful appendix. For its size, the book is expensive; this is doubtless because the publishers cannot expect to sell it in really large numbers, for its material is somewhat specialized. Yet for this very reason the Institute of Physics and the author are to be congratulated on their enterprise, for the book will be of great utility to many research workers in helping them to appreciate the possibilities—and limitations—of mass spectrometers.

D. F. BRACHER

"STRASBURGER'S TEXT-BOOK"

Lehrbuch der Botanik für Hochschulen

Begründet von E. Strasburger, F. Noll, H. Schenck und A. F. W. Schimper. 26. Neu Bearbeitete Auflage. Bearbeitet von Prof. Hans Fitting, Prof. Walter Schumacher, Prof. Richard Harder und Prof. Frantz Firbas. Pp. xii+651. (Stuttgart: Gustav Fischer Verlag, 1954.) 28 D. marks.

A FUTURE historian of botanical literature, surveying both sides of the Atlantic, may well regard the present period as the heyday of text-books, certainly of those that aim at instruction at the 'intermediate' level; the reflective, contemporary teacher may easily find himself wondering how long the large (and expensive) text-book will continue to hold its own in schools and universities. The volume being considered here is, of course, the one that has been long and widely known in its English translation as "Strasburger's Text-book". In parenthesis, we may perhaps note that the sixth and last English edition, translated by Prof. W. H. Lang and published by Messrs. Macmillan in 1930, was based on the seventeenth German edition. Now, in this, the twenty-sixth German edition, we may say that not only does the soul go marching on, but also the body, at least in its general framework, has remained relatively unchanged, although it has been appropriately brought up to date within the limitations of that framework. On the title-page acknowledgment is still made to its original authors of 1884—Strasburger and his colleagues—and in the prefatorial matter the comprehensive authorship of the several sections during the past seventy years is set out.

As in the earlier editions, the book begins with morphology, which is subdivided into cytology, histology and organography, with a short section dealing with the theory of descent and the origin of adaptations. In the second section, physiology is considered under metabolism, development (actually

changes of form) and movement, genetics and the effect of environmental factors being considered as subsections of the physiology of development. The third section, which deals with the systematic arrangement of plants from Schizophyta to Monocotyledoneae, retains the general form of earlier editions, though within some subdivisions and classes there has been extensive rearrangement. Some of these new taxonomic arrangements differ considerably from those in earlier editions and also from those in what may be described as recent standard works. The Algae afford one example of this, the retention of the concept of Pteridophyta another. As the materials in this section are necessarily very condensed, and as we have by no means come to a stage of finality in the resolution of the problems of taxonomy, it would be quite impossible in a short review to enter into detail on this aspect. The most evident single new addition to the original publication is the inclusion, since the twentieth edition, of a section on plant geography.

The reviewer of a broad conspectus of the subject such as this naturally tends to test it by scrutinizing in detail those sections with which he himself is most familiar. On the basis of this criterion it can be said that this new edition has been comprehensively modernized—review literature as recent as 1952 is cited in some of the sections—and that the student can gain access to representative recent and contemporary data and ideas, if not in the unavoidably condensed text, then from the judicious selection of literature cited at the end of the book. We have, in short, the qualities and limitations of the old substantial "Strasburger", with some of its coloured illustrations still retained, and still affording a comprehensive and representative survey of scientific botany in its many branches. C. W. Wardlaw

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PROGRESS IN PHYSIOLOGY, 1952–53

Annual Review of Physiology

Victor E. Hall (Editor), Jefferson M. Crismon and Arthur C. Giese (Associated Editors). Vol. 14, 1952; pp. x+589. Vol. 15, 1953; pp. x+558. (Stanford, Calif.: Annual Reviews, Inc.; London: H. K. Lewis and Co., Ltd., 1952–53.) 6 dollars each vol.

EVERYONE with any interest in physiology must be deeply grateful to those who produce the "Annual Review". The lists of contents of the volumes for 1952 and 1953 promise good reading, with an attractive mixture of young men and famous names. The editorial policy in choosing fields, the balance kept between basic physico-chemical aspects and the physiology of highly organized systems are admirable. The guidance to those preparing review articles for these volumes and the hope that the reviews will reflect the personal views of the author are obviously enlightened; and yet there is scarcely more than one article in each volume which one reads with pleasure as well as profit.

There are a few minor blemishes. It should be easy to remove more of the errors in English grammar of the European contributors, and one could wish that time permitted the correction of comments which seem to be unintentionally ambiguous. The real difficulty lies in the degree of responsibility which any one author feels able to accept for passing over nonsense in silence, praising discriminatingly, criticizing even widely accepted views, and on occasion proposing some new framework to carry the facts available.

Selection of papers to be mentioned cannot be easy. One author plaintively remarks that three thousand articles on the thyroid have appeared during the past two years. While the "Quarterly Cumulative Index" and the newcomer, the "Current List of Medical Literature of the U.S. Armed Forces Medical Library", are available, there is no need for "Annual Review" to catalogue. I feel that even more vigorous selection of titles is unlikely to leave many gems in obscurity, and that reviews with more than two hundred references are overladen and indigestible. Other evasions of duty include the habit of saying that "the results of this author are not consistent with current concepts". Surely this is simply sitting on the fence. To say that *A* says white but 'in contrast' *B* says black, usually means that the reviewer has not bothered to see if *A* and *B* are working in comparable conditions.

Here and there reviewers can be heard grinding their private axes; but with such a glorious opportunity the temptation must be difficult to resist. One practice which should be sternly suppressed by the editor is Prof. J. F. Fulton's habit of publishing extracts from letters from authors on their unpublished experimental results. Clearly the reviewer has little chance of judging for himself the significance of work reported in letters, and he is poaching on the preserves of the reviewer for 1955. Fulton includes an attack on cybernetics on the grounds that it offers nothing conceptually new and has spread unhappy confusion among students. I feel that cerebellar tremor should be considered from the point of view of stable and unstable feed-back mechanisms, instead of being ascribed, as it is now, to irregularities of muscle action. The present view seems both unhappy and confused.

Two most enjoyable papers were those of Alan Burton on "Peripheral Circulation" in the 1953 volume and J. R. Robinson and R. A. McCance on "Water Metabolism" in the 1952 volume. As a former physicist and for the past twenty years a biophysicist, Burton is well placed to castigate pretentious nonsense in physical aspects of physiology. His comments on "pulmonary capillary pressure", on the calculation of the area of stenosed mitral valve and on "coupled elastic rams" are well deserved. It is not surprising that while dealing such swingeing blows he is occasionally unkind and even unfair. More of such vigorous criticism would have a salutary effect on authors.

The paper by Robinson and McCance is chiefly memorable for an expansion of ideas put forward previously by Robinson. They state the current view that all cells are in osmotic equilibrium with their environment, together with the experimental discrepancies, and decide that the current theory is not worth preserving. The alternative, that active transport of water is occurring across the walls of most cells and that their apparent equilibrium is in fact a dynamic steady-state, seems to provide a better starting-point from which to appreciate the differences between tissues, and it makes it possible to begin the interpretation of whole ranges of data. Fortunately such changes in outlook occur rarely; but in its short history "Annual Review of Physiology" can boast of a few such papers to which we turn again and again. D. Whitteridge

British Association for the Advancement of Science Mathematical Tables

Vol. 10: Bessel Functions, Part 2, Functions of Positive Integer Order. Prepared on behalf of the Committee for the Calculation of Mathematical Tables by W. G. Bickley, L. J. Comrie, D. H. Sadler, J. C. P. Miller and A. J. Thompson. (Published for the Royal Society.) Pp. xl+255. (Cambridge: At the University Press, 1952.) 60*s*. net.

THIS volume, to quote the preface, is the last of the series of British Association Mathematical Tables and is thus both the fulfilment of a long-standing promise and the completion of a task. It forms a companion to Part 1 (Bessel functions of orders zero and unity), containing, as it does, tables of functions of integer orders from two to twenty, inclusive.

There is a comprehensive introduction of some forty pages consisting of page-index diagrams, an account of the preparation of the tables and the methods of interpolation used therein, together with a bibliography, a summary of notations and a most valuable list of the definitions of the functions and the relevant formulæ.

The tables themselves are divided into eight distinct sections. The first gives $J_n(x)$ for the arguments 0–25 to eight decimal places, and the second a similar table for $Y_n(x)$. In the third and fourth, the functions $e^{-x}I_n(x)$ and $e^{x}K_n(x)$ appear to eight figures for arguments 0–20. Second differences are provided in all four cases, and the interval of tabulation is generally 0·1, but in smaller arguments sometimes 0·01. The last four sections deal respectively with $J_n(x)$, $Y_n(x)$, $I_n(x)$, $K_n(x)$, the entries here being to ten figures with a uniform interval of 0·1. The ranges of argument are as before, but this time no special provision is made for interpolation.

Meticulous care has been taken in the preparation and reproduction of this series of B.A. Tables by all concerned, and this particular volume conforms to the usual high standards. J. H. PEARCE

Proteins and Enzymes

By Kaj Ulrik Linderstrøm-Lang. (Lane Medical Lectures.) (Stanford University Publications: University Series, Medical Sciences, Vol. 6.) Pp. ix+115. (Stanford, Calif.: Stanford University Press; London: Cambridge University Press, 1952.) 24*s*. net.

NO laboratory has devoted itself so long to the fundamental problems of protein chemistry as the Carlsberg, and in these lectures Dr. K. U. Linderstrøm-Lang has presented some of the topics pursued there during the past twenty years. If any short description is possible, it might be said that they truly reflect in the elegant simplicity of experiment and deduction the great tradition of Sørensen. The first two lectures describe the development and application of ultramicromethods in biology, a many-sided research to which Holter's name is inseparably linked. One feels here that artistry and science have shared equally in producing these beautiful methods, which have been applied to such varied material as moths, carnivorous plants, sea-urchin eggs, gastric mucosa, barley and *Chaos chaos*.

Two lectures are devoted to the initial action of proteolytic enzymes on proteins and the conversion of ovalbumin to plakalbumin. The latter has the greatest significance for interconversions which are much more important physiologically—the clotting mechanism and the activation of zymogens. This last topic is itself explored and discussed in relation to the action of proteolytic enzymes themselves: whether they initially accelerate the opening out of the protein molecule. The methods used, changes of rotation and molecular volume, are characteristically simple.

The last topic deals with the biosynthesis of the peptide bond—not, as the title declares, the biological synthesis of proteins. This is a most useful and precise account. It is appropriate to add that, in contrast to the factual impersonality of much scientific writing, most readers will appreciate the familiar style, the clarity and individuality of the presentation. KENNETH BAILEY

High Energy Nuclear Physics

Proceedings of the Third Annual Rochester Conference, December 18–20, 1952. Compiled and edited by H. P. Noyes, M. Camac, and W. D. Walker. Pp. iv+110. (New York and London: Interscience Publishers, Inc., 1953.) 2.00 dollars.

THIS record contains a résumé of the talks and discussions offered by the participants to the third annual Rochester conference on "High Energy Nuclear Physics", held during December 18–20, 1952. It is a very attractive record and one of the liveliest I have come across. This is due partly to the excellence of presentation and the topicality of the subject-matter offered. It reflects the spirit of informal discussion by reproducing the contributions in approximately verbatim form, often lightening controversial matters with speech and counter-speech.

The excellent summary by E. Wigner of the "Present Status of the Charge Independence and the Saturation of Nuclear Forces" opens the volume and is followed by contributions from various experts in the field. Next come the following: pion production and pion-nucleon scattering (under the chairmanship of E. Fermi); V^0 particles, generally only found in cosmic rays; and a session on the super-heavy mesons χ, $\varkappa$ and τ. Two chapters on theoretical field calculations and on experimental topics, respectively, complete the conference record. Of special interest to the experimental physicists in the last chapter are such exciting things as μ^- and π^- mesonic X-rays, and the decay of π^0 into positron and electron plus gamma-ray.

On the whole, one realizes the fact that our present knowledge of the properties of mesons and their interactions is very inaccurate and that it offers a wide field for the experimentalist who has access to big accelerators or is expert in cosmic-ray research. This conference report is essential for all research workers in this field and well worth reading by the general nuclear physicist. It costs only two dollars and is printed, fortunately, in big clear type.

E. BRETSCHER

A Handbook of Colorimetric Chemical Analytical Methods for Industrial, Research and Clinical Laboratories developed for use with the Lovibond Comparator

Pp. 119. (Salisbury: The Tintometer, Ltd., 1953.) 15*s*.

THIS handbook consists of a collection of methods of colorimetric analysis using the Lovibond comparator with standard coloured-glass disks appropriate to each determination. In all, sixty different determinations are described, dealing with *p*H measurements, the analysis of organic and inorganic substances, and clinical determinations of such varied substances as *p*-aminosalicylic acid, blood phosphatase and lead. The introduction and general

description—adequately illustrated—describe the general method of carrying out colorimetric determinations.

The succeeding sections deal with individual determinations, preceded in each case with the relevant references to the scientific literature. The methods, which are clear and concise, have been drawn up in collaboration with laboratories engaged in each determination. As in all colorimetric methods, it is assumed that the preliminary preparation has eliminated interfering substances and that the colour quality given by the test is precisely the same as the disks, which are permanent. As pointed out in the introduction, "if the colour of the test solution is different from the glass standards, it is a sure indication that the reagents are stale or wrong, or the technique has not been followed correctly". The colour quality of the light used is important, as there may be considerable metamerism between the colour of the test liquid and the coloured disks. The operator is therefore directed to use a "uniform source of white light, preferably a north window".

While the modern tendency is for the use of a spectrophotometer or photoelectric colorimeter instead of visual methods, it must be admitted that well-standardized and authenticated colorimetric methods such as described have distinct advantages in simplicity and speed, and avoid certain difficulties associated with complicated instruments. J. King

Yorkshire Birds

By Ralph Chislett. Pp. viii+335+10 plates. (London and Hull: A. Brown and Sons, Ltd., n.d.) 25*s*. net.

A NEW work on the birds of Yorkshire is very welcome, as many changes have taken place since Nelson and Eagle-Clarke's book was published in 1906. As is the case elsewhere, Yorkshire has suffered during the past quarter of a century from the increase of industrial development and intensive farming. The clearing of all deciduous woods and replanting with conifers has had a marked effect on the bird-life, and although the decline of game preservation and the breaking up of estates may have been good for birds of prey, it has led to a great increase in carrion crows, magpies and jays.

A chapter is devoted to these changes, and another gives a useful summary of bird migration in Yorkshire, both inland and on the coast. Spurn Point, at the mouth of the Humber, is an important point of arrival for migrants crossing the North Sea, and was formerly a great haunt of collectors. Now there is a trapping station where birds are caught and ringed, and much information is being collected on the movements of migrants on that part of the coast. The Brampton and Flamborough cliffs have long been famous as breeding places for vast numbers of sea-birds, including guillemots, razorbills and kittiwakes. Mr. Ralph Chislett writes that all is not well there: the kittiwakes have increased, but the numbers of guillemots and razorbills are much fewer than formerly, and this, he suggests, is owing to the over-collecting of their eggs and the mortality through oil pollution—a menace to which these birds are very susceptible. Certain species among the land-birds have also decreased; but, at the same time, others have increased. All this is well described in the author's interesting account of each species.

Mr. Chislett is to be congratulated on his volume, which will long remain the standard work on the birds of Yorkshire.

Volume and Integral

By Prof. Werner W. Rogosinski. (University Mathematical Texts.) Pp. ix+160. (Edinburgh and London: Oliver and Boyd, Ltd.; New York: Interscience Publishers, Inc., 1952.) 10*s*. 6*d*. net.

THIS small book provides an excellent introduction to the theory of the Lebesgue integral in n dimensions.

Part 1 is devoted to the problem of volume, the geometrical aspect of the integral being stressed throughout the book. First, sets of points are considered, and then the Peano–Jordan definition of content is discussed; this is followed by the Lebesgue definition of measure.

Part 2 first gives the theory of the Riemann integral of a function of n variables, defined geometrically (that is, in terms of 'volume'), using content as the underlying notion of volume. The Lebesgue integral is then dealt with in a similar way, on replacing content by measure. Finally, the theory of the indefinite integral of a function of one variable is discussed.

I agree with the author (see preface) that the elements of the theory of the Lebesgue integral should be included in a mathematical honours syllabus. This book, which is exceptionally clearly written, would well serve the purpose of teaching such matter. Some good examples are provided, with solutions at the end of each chapter; this is an additional recommendation in a book of a purely theoretical character. R. G. Cooke

Pétroles naturels et artificiels

Par J.-J. Chartrou. (Collection Armand Colin: Section de chimie, No. 124.) Troisième édition, entièrement refondue. Pp. 224. (Paris: Armand Colin, 1952.) 260 francs.

THIS typically uncut, paper-covered little volume, which fits the pocket comfortably, is the third edition, No. 124, of "Collection Armand Colin (Section de Chimie)". The author endeavours to cover a wide field of petroleum technology in 224 pages, size $6\frac{1}{2} \times 4\frac{1}{2}$ in. He states his object at the outset: to study physical and chemical properties of petroleum; exploitation and refining; a chemical industry based on petroleum products; substitute hydrocarbons and lubricants. Actually, he goes much farther than that curriculum, ambitious though it is for small space. Twelve chapters describe composition, chemical, physical properties of petroleum; geology, surface indications and exploration; exploitation by drilling, wells, shafts, galleries; storage, transport; refining; analysis, control of products; economic applications of products including chemically derived materials; world production; hazards in the oil industry. There is an afterthought on ozokerite and asphalt (two pages!); and an omnibus chapter, which includes oil shales, low-temperature carbonization, hydrogenation and synthetic products, completes the study. To me it seems a herculean task to attempt to cover in narrow compass all aspects of such a highly integrated and specialized technology as petroleum as it exists to-day, even in title. At best, it means synopsis; at worst, much severed outline. To the layman, much of this text is beyond him. To student or oil technologist, modern literature is now prodigious in its specialized subjects, and outlines as such are outmoded. Maybe there is a 'midway' public in French-speaking countries to which this little work will appeal; to this extent I wish it well. H. B. Milner

THE AMATEUR SCIENTIST IN BRITAIN (2)*

By R. BRIGHTMAN

IN the physical sciences the amateur is still rendering services. Maurice Gorham, former head of the Television Service of the British Broadcasting Corporation, has pointed out that broadcasting owes its resuscitation in the 'twenties to the amateurs[23]. Their activities, enthusiasm and incessant demands, culminating at the end of 1921 in a petition to the Post Office from sixty-three societies representing 3,300 amateurs asking for wireless telephony transmissions, "primarily to serve the scientific purpose of improving the receiving arrangements", but referring to weather reports, news, etc., which were already being received from foreign wireless stations, in a way that showed clearly that what they wanted went beyond purely scientific tests. This time the Post Office yielded and authorized the Marconi Company to broadcast speech and music for the amateurs, to the extent of one programme of fifteen minutes duration each week, and thus the first authorized broadcast made from Writtle on February 14, 1922, is due mainly to the activities of amateurs. At the present day, a new organization, to be known as the Radio Amateur Emergency Network, is being formed. When it is complete it will include some fifty key stations and about four hundred auxiliaries, all operated by amateurs. Most of the key stations are already linked. The amateurs operating the fifty key stations have all undertaken to provide emergency sources of power independent of the public electricity supply.

Again, Sir Edward Appleton has borne witness to the value of the pioneer work of D. J. Heightman and other amateurs in connexion with solar-radio noise[24]. Attention, he points out, was first attracted to this phenomenon by the reports of wireless amateurs who, round about the period of the last sunspot maximum, noticed the existence of a curious hiss in their receivers on wave-lengths of about ten metres, which they found to occur in day-time only, and to be associated with periods of solar activity. During the War, with the more sensitive and more directional ultra-short-wave receivers in operation, many further reports of the reception of this noise became available, and Sir Edward Appleton used the period of pronounced sunspot activity, January 30 to February 14, 1946, to make a special detailed study of the phenomena. His examination of the evidence available confirms the theory he and J. S. Hey had already advanced that the noise is due directly to ultra-short-wave electromagnetic radiations, which originate in active areas on the sun, and travel from the sun to the earth with the speed of light.

The intense radio-wave emissions from sunspots were also first recorded by war-time operators on Army *G.L.* equipment. When the *V2* rocket bombardment of London began, every method of giving even a few seconds warning was explored. Among these, radar equipments used by Anti-Aircraft Command were modified in the hope that the rockets would give a transient radar echo as they travelled high up in the atmosphere[25]. They did, but it was soon found that short-lived echoes were obtained and warnings given when no rockets were about. These spurious echoes were studied by J. S. Hey and his colleagues in the Army Operational Research Group, who eventually concluded that they were caused by meteors in the earth's atmosphere.

It is, of course, scarcely correct to ascribe such work to purely amateur effort. It is unlikely, for example, that anything would have arisen from this latter work had not a fully qualified scientist been responsible for investigating all such unusual occurrences, or had not the members of the Field Study Course been excavating under expert guidance. They do, however, illustrate the force of an observation made by Mr. Justice Lloyd-Jacob in his Bernard Dyer Lecture to the Society of Public Analysts[26]. Mr. Justice Lloyd-Jacob, suggesting that the most promising areas for future scientific growth are those that lie between the various well-established scientific fields, stressed the importance of collaboration of the right kind if these fields are to be developed. What is wanted, he suggested, is not so much the skill to experiment in the field of another scientist, but the competence to understand, to criticize and to appreciate the experiment and the results that the experiment secures. Upon such lines the most useful teamwork was done during the War, and had not secrecy considerations prevented the publication of many of the details of this collaboration, the concepts and characteristics of the scientist would not have remained so unfamiliar to most of his fellow-men. Mr. Justice Lloyd-Jacob observed that some better understanding of the scientist might have saved him from those dangers to which mob hysteria over nuclear-fission appear to expose him. It needs only superficial acquaintance with the outcome of security investigations in the United States, for example, to appreciate how real is the danger to science itself to which Mr. Justice Lloyd-Jacob alludes.

There are other reasons, however, why the wider public appreciation of the scientist and his work is desirable. In the introduction to his "History of the Rise and Influence of the Spirit of Rationalism in Europe", published in 1865, W. E. H. Lecky wrote:

"But when towards the close of the eighteenth century the decline of theological passions enabled men to discuss these matters in a calmer spirit, and when increased knowledge produced more comprehensive views, the historical standing-point was materially altered. It was observed that every great change of belief had been preceded by a great change in the intellectual condition of Europe, that the success of any opinion depended much less upon the force of its arguments, or upon the ability of its advocates, than upon the predisposition of society to receive it, and that that predisposition resulted from the intellectual type of the age. . . .

"The pressure of the general intellectual influences of the time determines the predispositions which ultimately regulate the details of belief; and though all men do not yield to that pressure with the same facility, all large bodies are at least controlled. A

* Continued from p. 565.

change of speculative opinions does not imply an increase of the data upon which those opinions rest, but a change of the habits of thought and mind which they reflect. . . .

". . . The doctrine, that the opinions of a given period are mainly determined by the intellectual condition of society, and that every great change of opinion is the consequence of general causes, simply implies that there exists a strong bias which acts upon all classes of men and eventually triumphs over every obstacle."

Mr. Justice Lloyd-Jacob's remarks remind us of Lecky's doctrine of the climate of opinion; but whereas Lecky had in mind particularly the way the discoveries of physical science were entrenching upon the domain of the anomalous and the incomprehensible, and by enlarging our conceptions of the range of law, and revealing the connexion of phenomena that had formerly appeared altogether isolated, had formed a habit of mind far beyond the limits of physical science, we, in our day, are more concerned with the way in which public ignorance or hysteria can limit the operations of science itself.

To take one or two examples:

The Report on the Conservation of Nature in England and Wales, published in 1947, observes[27]:

"In the long run the success of wild life conservation must depend predominantly on the completeness with which wild life problems and their implications are known, and on the extent to which public opinion accepts them and therefore gives support to the necessary measures of conservation.

"We are impressed with the futility of pursuing wild life conservation policies which are not widely understood and backed by public opinion, and of creating a multiplicity of offences or restrictions upon the liberty of the individual, in order to curb the misguided activities of very small sections of the population."

Similarly, Sir Arthur Tansley recorded the view that the establishment and fruitful functioning of national Nature reserves and a biological service would not be secured without a greatly increased permeation of the general mind with the outstanding importance of their objects.

Dr. E. A. R. Ennion, addressing in August 1950 the Conference of Delegates of Corresponding Societies at the British Association meeting in Birmingham, likewise observed[28]:

"Reserves cannot be administered properly by remote-control committees whether of strictly scientific or of predominantly sentimental composition. Still less could reserves be supervised successfully from a window in Whitehall. Their ultimate safeguard lies in the studied care and vigilance of amateur field naturalists up and down the land."

In August 1951, Dr. D. A. Allan[29], surveying the "Scottish Scene" in his presidential address to the same Conference at Edinburgh, remarked that the trained biologist required to supervise Nature reserves and to carry out ecological research involved, needed the support of "a special Home Guard of local amateur naturalists, including botanists, entomologists, ornithologists and zoological specialists".

Besides this scientific and practical aspect which obviously calls for a real effort at education, there is a cultural or spiritual aspect which is no less important. As the Huxley Committee observed[30], the educational benefits to be had from a constructive wild-life policy extend beyond the cultivation of a healthy public opinion and the technical training of science students to the wider sphere of general and adult education. In this context there is a quotation from the third report of the Nature Reserves Investigation Committee: "A serious student, whatever his calling, who could visit and have intelligently demonstrated to him even a good example of the sites here proposed, would have received a liberal education in one of the most stimulating and formative fields of thought". By building up an appreciation of the interest and beauty of Nature and public consciousness of the aims of conservation, the Huxley Committee considers that the adult educational facilities provided in the Nature reserves would complement and ease the work to be done in National Parks. Now that the Nature Conservancy is well established, it can be confidently expected that, with Mr. E. M. Nicholson as its director-general, who is probably even better known as an ornithologist than as the senior Civil servant who had been secretary to the Lord President's office since 1945, there will be no failure to cultivate the amateur's support and co-operation, and that the Conservancy will encourage and, where possible, extend voluntary efforts in the field of research, especially ecological research, for which it is responsible.

This is not all, however. Prof. S. W. Wooldridge has stated that at no time did the youth of Britain need more greatly to be shown the mental stimulus combined with solace of mind and spirit which come from learning to read and understand the country[31]. It is of vital importance that interest in Nature and in living things should be stimulated and encouraged by every possible means. Only by strengthening this side of people's minds can we hope to counter excessive preoccupation with stark mechanism and the crude materialism to which it often leads—so dangerously characteristic of modern civilization—by a deeper understanding of living beings and of life. Sir Arthur Tansley[32] also has urged that this is as important to the continuation of civilization as an ever-deepening understanding of Nature and of the complex structure and working of her productions is the very foundation of most of man's practical activities—in the first place his own physical and mental health, then agriculture and the care of animals, and then such pursuits as forestry, control of pests, water supply, drainage, and so on.

The work of the Council for the Promotion of Field Studies, formed in December 1943, largely on the initiative of Mr. F. H. C. Butler, its present director, is appropriately considered in this context. Briefly, the aims of this Council, which was incorporated on June 13, 1946, are to provide facilities for every aspect of field-work at first hand, and to set up for this purpose residential field-study and research centres, distributed throughout the country, in localities selected for the richness and variety of their ecological features, geological and geographical interest and archæological and historical importance. The field-centres are available alike to all serious workers in the field, whether amateur or professional, whether as individuals or as members of a class from a school, training college or university; from a county college, technical college or youth service; whether as independent workers or as members of a research team, learned society or other corporate body. The Council wishes to co-operate closely with local societies and field clubs, and through the centres should also be able to play an important part in the training of the community in sound knowledge.

æsthetic appreciation and proper use of the countryside. The centres are intended just as much for the individual "amateur nature lover" as for parties from universities, training colleges and schools; in fact, it is one of the aims of the Council to encourage and help the ordinary person with an interest in some branch of natural history who wishes to learn more of this or allied subjects. It is precisely because they are not directly concerned with education that 'amateurs' contribute to a mixed party the spirit of genuine interest and enthusiasms which has nothing to do with examination results. Their contribution to any course is correspondingly valued. They are so often people of wide experience that they have a special contribution to make to discussion and argument on any course, and the work of the centres suffers accordingly when there is none in residence.

Since the first of the field-centres opened its doors at Flatford Mill in May 1946, more than 5,000 resident students have passed through them and the amateur naturalist has been accepted on a really large and comprehensive basis[33]. There are at present four such centres situated in totally contrasting types of country. Flatford Mill itself is specially well placed for the study of hydrobiology, and it is hoped here to develop besides long-term recording of hydrobiological conditions, including temperature changes in a slow-moving river, a training ground for ecological research. The Juniper Hill Field Centre, near Dorking, offers opportunities for the geographical interpretation of landscape, the siting and growth of settlements, plant and animal ecology and general nature study on the North Downs, the western Weald and the outer fringe of the London basin. The Dale Fort Centre, near Haverfordwest in Pembrokeshire, is particularly adapted for the study of bird life and marine biology and the ecology of a rocky coast. It offered in August 1952 for family parties, as an experiment, a holiday course based on the wind and the sea. An integral part of this Centre is the Skokholm Island Bird Observatory. The Malham Tarn Field Centre near Settle offers opportunities for the study of bird life and mammal life in characteristic limestone regions of the Yorkshire dales, including also courses on insects and on fungi, liverworts and mosses. One feature of the work at this Centre has been the annual collaboration since 1950 of the Royal Meteorological Society in a course held in September, and each of these four centres estimates the students in residence, generally for a week at a time, at 1,000–1,200 for the season.

While the need for facilities for field-work in Britain is thus increasing and the opportunities which the Council can offer are more important year by year, the Council finds increasing difficulty in maintaining its centres. It has already been compelled to raise its weekly charges to students to five and a half guineas, and although some firms like Imperial Chemical Industries, Ltd., have made substantial annual grants under deed of covenant in favour of the Council, much more support is required both from industry and from the scientific societies and other bodies if all the possibilities which the Council's work offers for encouraging the activity of both the professional and the amateur scientist in field studies are to be utilized to the full.

It should be apparent from the foregoing account that already much is being done in Great Britain to close the gap between the professional scientist and the amateur, or indeed the layman generally. In few countries have amateur naturalists made such important contributions to biological knowledge over so long a period as in Great Britain, but since the War there have been remarkable developments in other countries. In a paper reviewing the tenth International Ornithological Congress at Uppsala in 1950, where the large British party included characteristically strong amateur elements, Dr. Julian Huxley referred to the way the interest of the amateur in ornithology had been enlisted since the previous Congress in 1938. Besides the founding of the British Trust for Ornithology, which carries out various scientific investigations almost wholly from the efforts of amateurs, the Swedish Ornithological Society had grown to more than 1,500 members, mostly amateurs, since its foundation in 1945, and there have been similar developments in the United States, Holland and elsewhere. As a result of this, many men and women who would, at best, have become amateur bird-watchers or sentimental bird lovers, have become interested in the scientific aspects of bird life, and have had the satisfaction of helping in research and the advancement of scientific knowledge. Dr. Huxley instances important new knowledge, for example, on the fluctuation in numbers of particular species (like the common heron or the great crested grebe) within a country or region over a period of years, or the relation of clutch-size and of egg and fledgling mortality to geographical position and climatic variation, as discovered only through the co-operative efforts by amateurs. The British Trust for Ornithology itself, which exists to encourage observation by amateurs and to publish the results, has, in addition to the inquiries it has completed into the numbers and habits of rooks, the decrease of the corn-crake and the distribution of the woodcock, for some years been investigating the changes in the population of heronries in relation to the weather and the remarkable spread of the fulmar. The new Observatory on Bardsey Island, off the Lleyn Peninsula of Caernarvonshire, which is now making an appeal for funds on the lines adopted by the Fair Isle Bird Observatory of Northern Scotland, is the latest of twelve such observatories to be established in the British Isles, and the fourth along the west coast. It owes its foundation to the initiative of the West Wales Field Society and the Birmingham and West Midland Bird Club, and will offer opportunities for work by amateurs, particularly in setting up the bird-catching traps and devices for the capture, marking with numbered leg-rings, and release of migratory birds.

In the United States in 1938 the Carnegie Corporation and the American Philosophical Society set up a Committee on Education and Participation in Science which surveyed the activity of more than seven hundred amateur scientists in the Philadelphia region and helped organize a number of research projects in which very many more participated. Out of this came "The Amateur Scientist", a book written by the secretary of the committee, W. Stephen Thomas[35]. At about this time, too, a Committee on Private Research, also supported by the Carnegie Corporation, was set up at Western Reserve University for work in the Cleveland area. Many of the studies of amateurs with which it was concerned were in the sciences. The activities of this committee are described in a book by its director, William S. Dix, entitled "The Amateur Spirit in Scholarship"[36]. The War unfortunately prevented an extension of

these promising experiments. The American point of view is also well indicated in the presidential address to the American Association for the Advancement of Science of E. W. Sinnott, in December 1949[37]. In that address, entitled "Ten Million Scientists", Dr. Sinnott pointed out that we sometimes forget the vast areas where facts and principles of great scientific value may be discovered with no more complex tools or techniques than are at the command of any intelligent layman. He instanced the exact distribution of plant and animal species, the records of flowering dates, the analysis of tree-ring chronology, the variability of wild species, bird censuses and the records of bird and insect migrations, the study of peat borings, the collection and identification of fossils, the distribution of minerals, detailed local weather observations, records of meteorites and of variable stars, time-lapse photography, and problems of radio transmission, as but a few of the many fields open to study by the amateur scientist, and he added that a fresh point of view and freedom from bias have often led the amateur to discoveries that his more inhibited professional brother had overlooked.

The latest Directory of Natural History Societies lists some 124 such societies in Great Britain. Some societies, such as the Geologists' Association, Geographical Association, Amateur Entomologists' Society, Radio Society of Great Britain and British Astronomical Association, have among their members a considerable proportion of young people. The Amateur Entomologists' Society has some two hundred members in a special category of junior membership, and the Radio Society of Great Britain has about five hundred. The Royal Society for the Protection of Birds, besides having a special subscription for those under twenty-one, organizes a Junior Bird Recorders' Club. This was founded in 1943 and has now three thousand members between eleven and eighteen years of age. Members record observations of birds, which are used in producing an Annual Bird Report. Altogether there are some four hundred societies in Great Britain the interest of which include one or more branches of science, and these have already co-operated in such matters as the Land Utilization Survey; British Museum (Natural History), bird-ringing scheme, insect immigration scheme; London Natural History Society, bird report; Royal Meteorological Society, phenological report; Rothamsted Experimental Station and National Institute for Agricultural Botany, crop experiments.

With the growing dependence of scientific work upon State, or at least public rather than private support, it is more than ever important to secure such a public understanding and favourable climate of opinion if scientific work is not to be liable to continual and frustrating interruptions at every time of financial stringency. A volume of studies and sketches which Prof. J. Simmons published in 1952 under the title "Parish and Empire"[38] constituted an eloquent plea for field research and historical approach over a wide range of what may be termed local studies. He directs attention, for example, to the general neglect of industrial history and shows how parish studies can be linked up with national and imperial history. He indicates how the study of local history can contribute not merely to the clearer understanding of some of our modern problems, but also to redress some of the dangers inherent in specialization to-day. Local studies of this type could make their own contribution to the promotion of a wider general understanding in the community of the nature of scientific work and thus indirectly to the creation and maintenance of the conditions in which scientific activities truly flourish. That, as has been indicated, is one essential element in securing the continuous public support which the effective prosecution of scientific effort under the conditions of to-day demands. It is fostered also by the very existence of the amateur scientist and his wide distribution among all sections of the community. Lastly, as for the past three centuries, the contribution of the amateur is important in itself: even to-day, without the help of the amateur scientist the prosecution of research on the scale desirable into many problems of ornithology, meteorology and other problems embraced in ecology would be impossible. In such fields, with Britain's limited resources of scientific man-power, the co-operation and enthusiastic support of the amateur scientist are indispensable for the most effective deployment of our trained professional scientists.

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[28] *Advancement of Science*, **7**, 285 (1950).
[29] *Advancement of Science*, **8**, 279 (1951).
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[31] "The Spirit and Significance of Field Work" (C.P.F.S., 1948).
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[33] cf. also *Nature*, **167**, 712, 757, 801, 886 (1951).
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THE OLDEST DATED MINERALS OF THE RHODESIAN SHIELD

By Prof. ARTHUR HOLMES, F.R.S.
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FOR some years it has been suspected that the Rhodesia–Tanganyika Shield might include some of the oldest rocks of the African continent[1]. This has now been confirmed by the dating of monazites supplied by Dr. A. M. Macgregor and the Director of the Geological Survey of Southern Rhodesia. Through the good offices of Dr. F. H. Burstall, these minerals have been analysed chemically at the Chemical Research Laboratory, Teddington, for lead, uranium and thorium, and samples of pure lead iodide prepared from each. The proportions of the isotopes in the lead of these samples have been determined by Messrs. William C. Erickson and John Hoffmann in the laboratory of Prof. Alfred O. Nier at the University of Minnesota. The generous collaboration of these friends and fellow-workers is gratefully acknowledged.

The analytical data are recorded in Table 1, together with the crude, uncorrected ages, as read from Wickman's graph[2]. The highest uncorrected

Table 1

(Analyses by the Chemical Research Laboratory, Teddington)

	Pb	U	Th	Pb/(U+Th)	U/(U+Th)	Uncorrected age
1.	0·34	0·074	2·39	0·138	0·03	2,680 m.y.
2.	0·95	0·19	9·36	0·100	0·02	2,020 m.y.
3.	0·53	0·09	8·15	0·070	0·01	1,500 m.y.

1. Monazite from pegmatite, Ebonite Tantalum Claims, Bikita District, Southern Rhodesia.

2. Monazite from pegmatite, Jack Tin Claims, north of Salisbury, Southern Rhodesia.

3. Monazite concentrate from alluvium derived from "Lower Basement" rocks, Irumi Hills, about 90 miles east of Broken Hill, Northern Rhodesia.

age, that of the Bikita monazite, 2,680 million years (m.y.), needs very little correction, which is a highly satisfactory result in view of the extreme age of the mineral.

The first published indication of the great age of the Southern Rhodesian pegmatites was provided by Ahrens[3], who found the mean 'ages' of nine lepidolites, as determined by the strontium/rubidium spectrochemical method, to range from 1,900 ± 200 to 2,950 ± 300 m.y. Four of the specimens, including the 'oldest', were from the Bikita District, the mean of nineteen determinations (ranging from 1,700 to 3,300 m.y.) being 2,400 ± 200 m.y. It is stated that all these measurements were calibrated in terms of a standard lepidolite from south-east Manitoba, the age of which was taken as 2,200 m.y. This value is almost certainly too low, 2,500 m.y. being more probable[4]. Adopting this figure, the mean of all Ahrens's Bikita results is increased to 2,700 m.y. The close agreement with the corresponding lead age is of great interest; but the wide range involved (1,930–3,750 m.y.) emphasizes Ahrens's own warning[5] that as yet the strontium ages "of these most ancient rocks should not be taken too rigorously". In addition to the random errors inherent in spectrographic analysis, there appears to be, *inter alia*, a systematic error leading to abnormally high 'ages', the source of which is now being actively sought. The discrepancies cannot be altogether due to the original presence of inherited strontium, for even mass-spectrometric methods give results that are manifestly too high; for example, for lepidolite from Pope's Claim, Southern Rhodesia, belonging to the same cycle of plutonic activity as the Bikita minerals, an 'age' of 3,740 m.y. has been claimed[6], whereas Ahrens's estimate for lepidolite from the same locality was only 2,150 m.y. ± 10 per cent. (Since this article was completed, Prof. J. T. Wilson has informed me that the age of microlite from Pope's Claim has been determined in his laboratories at the University of Toronto from the ratio of radiogenic lead-207 to radiogenic lead-206 and found to be 2,600 ± 100 m.y. I am indebted to Prof. Wilson for permission to announce this important result.)

The older rocks of Southern Rhodesia are curvilinear synclinal schist belts enwrapped by migmatites and granites. Three systems have been distinguished in the schist belts: (1) the *Sebakwian*, characterized by granulites and metamorphosed ultrabasic rocks; followed, after folding, granitization and erosion, by (2) the *Bulawayan*, characterized by banded ironstones and volcanic rocks, including pillow lavas; followed in turn by (3) the *Shamvaian*, a mainly sedimentary system which, together with the older rocks, was later folded and locally granitized. A suite of pegmatites of lepidolite-greisen type with a lithium, beryllium, tin, tantalum, tungsten mineralization is associated with the later granites. Of many of the mineralized pegmatites it is only known by direct evidence that they are post-Bulawayan, but since some of them cut the Shamvaian formations and the others have not been metamorphosed, it is probable that the whole suite is post-Shamvaian[7].

The Bikita monazite (Table 2) is a concentrate from a post-Bulawayan tantalite-bearing pegmatite situated about four miles south-west of the main Bikita tin field[8]. If the proportion of lead-204 can be regarded as negligible, the four 'ages' are in remarkably close agreement. If an extreme correction for original or inherited lead be made, taking lead-204 as 0·0007, the four 'ages' become (respectively as in Table 2):

2,600 ± 30; 2,670; 2,615 ± 15; 2,640 ± 25 m.y.

The sequence of the first three[9] indicates a very slight deficiency of uranium, which might be due to natural alteration of the mineral or to a slight error in the analysis. In neither case would this affect the

Table 2

(Isotopic proportions determined by William C. Erickson and John Hoffmann in the Laboratory of Prof. Alfred O. Nier)

1. Monazite, Ebonite Claims, Bikita, S.R.				
	Pb^{204}	Pb^{208}	Pb^{207}	Pb^{206}
Isotopic proportions	<0·0007	1·000	0·180 ± 0·004	9·36 ± 0·09
Radiogenic lead (per cent)	—	0·032	0·006	0·307
	Pb^{207}/Pb^{206}	Pb^{208}/U	Pb^{207}/U	Pb^{206}/Th
Lead isotope ratios	0·18	0·433	0·078	0·128
'Ages' in m.y.	2,680 ± 30	2,675	2,680 ± 15	2,645 ± 25
2. Monazite, Jack Tin Claims, North of Salisbury, S.R. (headings as in No. 1)				
Isotopic proportions	0·00469 ± 0·00004	1·000	0·233 ± 0·001	12·04 ± 0·04
Original lead*	0·00469	0·060	0·087	0·154
Radiogenic lead	—	0·940	0·166	11·886
Radiogenic lead (per cent)		0·067	0·012	0·851
Lead isotope ratios	0·177	0·354	0·063	0·091
'Ages' in m.y.	2,650 ± 10	2,260	2,470 ± 10	1,940 ± 5
3. Monazite, Irumi Hills, N.R. (headings as in No. 1)				
Isotopic proportions	0·0123 ± 0·0002	1·000	0·3215 ± 0·002	16·04 ± 0·08
Original lead	0·0123	0·156	0·1759	0·40
Radiogenic lead	—	0·844	0·1456	15·64
Radiogenic lead (per cent)		0·028	0·005	0·522
Lead isotope ratios	0·173	0·313	0·054	0·064
'Ages' in m.y.	2,620 ± 10	2,040	2,330 ± 15	1,390 ± 10

* For the original lead that existed about 2,600 m.y. ago, the isotopic constitution adopted is 1 : 12·7 : 14·3 : 32·8

age calculated from the ratio of lead-207 to lead-206, which may therefore be accepted as a minimum value. Apart from the standard deviation, one can only conclude that the age of the Bikita monazite is less than 2,680 and more than 2,600 m.y., suggesting that the most probable age is about 2,640 m.y., as given by the ratio lead-208 to thorium.

The monazite from the Jack Tin Claims (Table 2) is a concentrate from a post-Bulawayan pegmatite worked for tin and tantalum north of Salisbury. The 'age pattern' in this case clearly points to loss of lead[9], in which case the most reliable age is that given by the ratio lead-207 to lead-206, namely, 2,650 ± 10 m.y.

The monazite from the Irumi Hills of Northern Rhodesia (Table 2), near the southern extremity of the Katanga pedicle, is a concentrate from alluvium derived from the rocks of the "Lower Basement" Group. Although nearly all the crystals are clear and apparently unweathered, the 'age pattern' indicates that the mineral has, in fact, been considerably altered. Loss of lead is the dominant effect, accompanied in this case by subsidiary loss of uranium. The only age indicator of value is the ratio lead-207 to lead-206, which remains unaffected by recent weathering and would be only slightly reduced by alterations that occurred long ago[9]. The age given by this ratio, 2,620 ± 10 m.y., may therefore be a trifle less than the true value. The accordance of this result with those recorded above adds convincing support to Guernsey's provisional suggestion —based on lithological and tectonic similarity—that the Lower Basement rocks of Northern Rhodesia may be partially equivalent to the Bulawayan System[10].

The Bulawayan rocks represent sediments and lavas that were deposited or erupted at the earth's surface considerably earlier than the period of pegmatite formation here dated at about 2,640 ± 40 m.y., especially so if the pegmatites concerned are post-Shamvaian, as is highly probable. Since these pegmatites are not only the oldest dated examples known in Africa but are also the oldest yet recorded for any continent, it is interesting to direct attention to their bearing on the time during which life is known to have existed on the earth. In 1935, Dr. A. M. Macgregor detected algal structures in graphitic limestone (33 miles north-north-east of Bulawayo) associated with cherts and lavas low down in the Bulawayan System, which at that time was known as the Greenstone System. In 1941, the structures were described and figured[11]. This important discovery by Macgregor, and the age determinations now recorded, provide indubitable evidence that life has existed for at least 2,600 m.y. and probably for considerably longer than 2,700 m.y.

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OBITUARIES

Dr. F. M. Penning

Frans Michel Penning was born on September 12, 1894, at Gorkum in The Netherlands. He studied physics at the University of Leyden under Kamerlingh Onnes, and his thesis on isopycnic curves of gases at low temperatures is in keeping with the Leyden traditions of those days. In 1924 he joined the research laboratories of the Philips Company at Eindhoven, and there he remained until his death on December 6, 1953, devoting his activities almost exclusively to the study of the electric discharge in gases, a field in which he soon became a prominent figure.

A characteristic feature of his work was his continual effort to obtain reproducible results under well-defined conditions. With great skill and patience he carried out a number of carefully designed experiments to determine fundamental constants relating to discharges in gases. This work also led to brilliant new discoveries.

Penning was the first to recognize that the breakdown potential of inert gases can be profoundly modified by small quantities of other gases which may become ionized by collision with metastable atoms of the original gas. This concept enabled him not only to explain the discrepancies between existing data but also to discover a number of new and striking phenomena.

A second aspect of his work dealt with discharges in magnetic fields. One of his results was that, in a magnetic field with a certain electrode configuration, a discharge can subsist at very low pressures. This led to the development of the Penning type of ion source and of the Penning ionization gauge, both of which are valuable tools in modern experimental technique.

In the years after the Second World War, Penning made further important progress in obtaining reproducible values of the cathode fall on a molybdenum electrode by showing how the influence of oxides and other impurities can be eliminated by an elaborate sputtering technique. This work led also to the development of a new stabilizing tube.

Mention should also be made of his article with de Groot on the excitation of quantum transitions by collisions, in "Geiger und Scheel's Handbuch der Physik" (1930), and of the well-known review article with Druyvesteyn (*Rev. Mod. Physics*, 1940).

Although handicapped by delicate health, Penning was not only a very hard worker but also a man with broad interests. Those who had the privilege of knowing him personally will remember him as a loyal friend and unselfish colleague, who to a rare degree had attained harmony between his personal faith and his daily life. H. B. G. Casimir

Dr. N. G. Horner

Dr. Norman Gerald Horner, who died on March 7, was editor of the *British Medical Journal* from 1928 until 1946, and for eleven years before that he was assistant editor under Sir Dawson Williams. Dawson Williams was an exacting chief, who was held in awe by his staff and colleagues; but Horner, a man of very different constitution and manner, became his devoted disciple, even to the extent of a (probably unconscious) change of literary

style. In his early days, Horner—one of those people who have a feeling for words and a sense of their value—contributed lightheartedly to his school magazine at Tonbridge, and to St. Bartholomew's Hospital *Journal*, of which he was editor for a time; but when, after serving in the First World War, he joined the staff of the *British Medical Journal* he quickly acquired its discipline and devoted himself to the precise writing and editorial revision which a scientific journal demands. His use of language was scrupulous, and any infelicity or slovenliness in phrasing he would regard as a form of discourtesy. But he was also a man of businesslike ability and resource, exemplified particularly on two occasions, one of them the general strike of 1926, when two issues of the *Journal* appeared in a very attenuated form indeed, but nevertheless appeared, and the other the occasion in 1941, when the printing office was destroyed in an air raid and the most extraordinary improvizations had to be made.

In the latter years of his editorship the British Medical Association became responsible for a number of special journals dealing with different aspects of medicine. Some eight of these were running by the time Horner left Tavistock Square, and although he did not take a major part in starting them they owed a good deal to his suggestions and to the tradition of responsible editorship which he always followed and which he strove to inculcate in others.

Apart from his editorial work, his interest was in the history of medicine. His M.D. thesis in 1922 was on the growth of general medical practice in England. He was honorary secretary and afterwards vice-president of the Section of History of Medicine of the Royal Society of Medicine. After his retirement he assisted in the compilation of the "Medical History of the Second World War".

Horner was editor during a troubled period which comprised not only a world war but also vital change in the medical profession itself. He was handicapped by ill-health; but he maintained throughout his years of office a great integrity, a desire quietly and without special recognition to serve the profession to which he belonged, and to his colleagues and staff he was invariably sympathetic and ready to give a discerning praise where praise was due.

Prof. P. C. Sarbadhikari

Dr. C. P. Sarbadhikari, the well-known Indian cytologist, who died on December 27 in his fifty-sixth year, was professor of botany and head of the Botanical Department of the University of Calcutta. As a young man he studied under the late Sir John Farmer at the Imperial College of Science and Technology, London, and obtained the D.Sc. of the University of London for a series of researches on the cytology of *Osmunda* and *Doodia*. He also studied for shorter periods at Wisley, Kew, Merton, Berlin-Dahlem, and at the University of Paris under Prof. Guilliermond. In 1925 he was appointed lecturer in botany at University College, Colombo, and later became professor there. In 1947 he went to Calcutta to the post which he occupied at the time of his death.

Prof. Sarbadhikari was the author of numerous papers on a variety of botanical topics. His chief contributions lay in the field of morphology and cytology. Specially notable are his researches on the cytology of apogamy and apospory in ferns. A man of considerable culture, he did much to develop botanical study and research in India.

NEWS and VIEWS

Mathematics at Glasgow: Prof. T. M. MacRobert

Prof. T. M. MacRobert, who retires in September from the chair of mathematics in the University of Glasgow, has made valuable contributions over the past thirty-five years to the theory of various special functions of analysis. His earlier papers dealt mainly with asymptotic expansions of these functions, and were followed by papers dealing with the addition theorem for Legendre functions, and series and integrals of these functions regarded as functions of their degrees. In 1937 Prof. MacRobert introduced the *E*-function, a generalized hypergeometric function, which has proved extremely fruitful for the study of confluent hypergeometric, Bessel and Legendre functions. His more recent papers are mainly concerned with the study of the properties of the *E*-function. He is the author of a number of well-known treatises on mathematics, of which the best known are "Functions of a Complex Variable" and "Spherical Harmonics". During his twenty-seven years as head of the Department at Glasgow, Prof. MacRobert has seen a large increase in the numbers of his staff and of his students, and it was on his initiative that a major scheme of reconstruction was carried out in 1950, involving the conversion of a large hall into a library and a set of lecture, tutorial and staff rooms. Prof. MacRobert was a member of the group of mathematicians who founded the Glasgow Mathematical Association in 1927. He has taken a prominent part in all its activities and has been the moving spirit behind the inauguration of its *Proceedings*, which, published with the co-operation of the University Court, were first issued in 1951.

Prof. R. A. Rankin

Prof. MacRobert will be succeeded by Prof. R. A. Rankin, at present Mason professor of pure mathematics in the University of Birmingham. Prof. Rankin was appointed to the Birmingham chair in 1951 (see *Nature*, **167**, 840; 1951).

Cytogenetics in the University of London: Prof. P. C. Koller

The University of London has conferred upon Dr. Peo Charles Koller the title of professor of cytogenetics, in respect of the position which he holds in the Chester Beatty Research Institute (of the Institute of Cancer Research, Royal Cancer Hospital). Dr. Koller has successively worked at the Kaiser Wilhelm Institute, Berlin (under Prof. R. Goldschmidt), at Cambridge where he studied genetics under Prof. R. C. Punnett, at the Institute of Animal Genetics in the University of Edinburgh (with Prof. F. A. E. Crew), at the Biological Research Institute, Tihany, as head of the Department of Genetics, and at the

John Innes Horticultural Institution with Dr. C. D. Darlington. He also spent one year in the California Institute of Technology, as Rockefeller Fellow, under Prof. T. H. Morgan. Before the Second World War he was closely associated with Prof. H. J. Muller in an investigation of the cytological effects of ionizing radiations on normal and malignant cells, and was later engaged in research on the effects of mustard gas, lewisite and similar substances for the Committee on Chemical Warfare. Dr. Koller was appointed to the Royal Cancer Hospital in 1944, and to the Chester Beatty Research Institute in 1946, where he has carried out a special investigation of the chromosomal and other abnormalities induced by chemical and physical carcinogens. He is the author of numerous papers in the scientific literature, including a specially notable series on the genetical and mechanical properties of the sex chromosomes in a variety of animal species.

George Newport, F.R.S. (1803–54)

George Newport, who died a century ago on April 7, 1854, is an impressive example of a man who raised himself from a humble origin to scientific eminence and who, despite his lack of early training, made a number of original and enduring contributions to natural history. Born on July 4, 1803, at Canterbury, the son of a wheelwright, he was from early boyhood fond of reading and drawing and was an ardent collector of insects. Deciding on a medical career, he entered the University of London (University College) in 1832, and three years later became a member of the College of Surgeons. He took up surgical practice in London, but was far too interested in microscopical studies to earn his living. Fortunately he had many influential friends, and in 1847 Sir James Clarke secured for him a pension from the Civil List of £100 a year. A patient, accurate observer and a facile dissector, Newport published several important papers (*Phil. Trans. Roy. Soc.*), and his communication in 1851 entitled "On the Impregnation of the Ovum in the Amphibia", in which he demonstrated that impregnation by spermatozoa is the result of penetration and not of mere contact, won him one of the Royal Society's Royal Medals. Many honours came his way in his short life: he was elected an honorary member of the College of Physicians in 1843, a Fellow of the Royal Society in 1846, and a Fellow of the Linnæan Society in the following year, and served as president of the Entomological Society during 1844–45. He died at the early age of fifty-one of a "fever of a typhoid character".

The Scottish Economic Society

The Scottish Economic Society is the new name of the Scottish Society of Economists, which was founded in Edinburgh in 1897, and was for a long time associated with the name of Prof. Shield Nicholson, its first president. Its revised constitution, with its new name, was ratified at a meeting held in the University of Edinburgh on March 16. The Society's chief aims are to advance the study of economic and social problems on the widest basis, in accordance with the Scottish tradition of political economy inspired by Adam Smith, and to encourage the discussion of Scottish economic and social problems. In furtherance of these aims, it published on March 16 the first issue of its new journal, the *Scottish Journal of Political Economy*, to appear three times a year. Some part of each issue will be devoted to Scottish affairs, either in articles, or in editorial notes, statistical notes on recent social and economic trends, or reviews or review-articles dealing with recent books or official papers relative to Scotland. But there is no intention to limit the contents of the *Journal* either to Scottish contributors or to Scottish problems. The subject-matter of political economy will be interpreted widely, in the tradition of Adam Smith, and articles on economic theory, economic history, sociology, demography and administration, as well as economic theory, will be considered. It is designed to appeal to a wide audience—not exclusively one of professional economists, but including, for example, historians, business men, bankers, accountants, actuaries, Civil servants, trade unionists, and all serious students of Scottish affairs. Members of the Scottish Economic Society, whose annual subscription is one guinea, will receive the *Journal* without additional charge.

The first president of the new Society is Lord Bilsland, banker and industrialist, and chairman of the Scottish Council (Development and Industry). The vice-presidents are Sir Alexander Gray and Dr. M. T. Rankin, who was a senior office-bearer of the old Society. The editor of the *Journal* is Prof. A. K. Cairncross, of the chair of applied economics in the University of Glasgow, who is assisted by an editorial board consisting of the professors of political economy in the four Scottish Universities and the secretary of the Society, Mr. T. A. F. Noble, lecturer in political economy, King's College, University of Aberdeen. The other members of Council are widely representative of business, banking and professional interests in each University region of Scotland. The treasurer of the Society, to whom applications for membership should be sent, is Mr. David Flint, of Mann, Judd, Gordon and Co., 142 St. Vincent Street, Glasgow, C.2.

Imperial College of Science and Technology, London: Report for the Year 1952–53

The Government announced, on January 29, 1953, that it intends to provide for the major expansion of the Imperial College of Science and Technology, London, and commenting on this the governing body of the College, in its forty-sixth annual report for the year ended July 31, 1953 (pp. 55; 1953), points out that two aspects have to be considered: first, to decide what is academically most desirable; and secondly, to devise an architectural plan designed to provide the necessary academic facilities, largely by building on land at present used by other institutions for other purposes, without the knowledge when the land will be available to the College builders. The governing body emphasizes its satisfaction at the Government's decision, and in the meantime records the building of a further extension to the Department of Metallurgy, improvements to the John Farmer (botany) building for the Department of Plant Physiology, and the purchase of a further 93 acres of land for the Field Station at Silwood Park, Sunninghill, and of the vacant site at 184 Queen's Gate, London, S.W.7. In view of the success of the lunch-time functions organized to encourage general studies in the College, the experiment is being continued for a further year, as is the joint experiment with the London School of Economics in arranging joint postgraduate studies in technology, economics and administration. Of the 1,653 full-time students (only 47 women), 114 came from foreign countries, 198 from Commonwealth countries outside the

British Isles, and 538 from the British Isles outside a radius of thirty miles from the College. The accumulated excess of expenditure over income has been reduced from £19,152 to £1,458. The usual valuable list of published papers, arranged departmentally, is appended to the report.

Use of Aircraft in Agriculture

In 1952 the Food and Agriculture Committee of the Organization for European Economic Co-operation sponsored a mission to the United States to study the use of aircraft in agriculture, with the view of promoting its development in Western Europe. From its report (Technical Assistance Mission No. 107; O.E.E.C., 2 rue André-Pascal, Paris 16e) it is evident that great advances in this technique have been made since the Second World War, largely owing to the discovery of new synthetic insecticides and weed-killers suitable for low-volume application, and the availability of adaptable war-surplus aeroplanes. In the United States some seven thousand aircraft, compared with sixty-five in Western Europe, are now in use, chiefly for pest and disease control, seeding and fertilizing. While it is recognized that conditions in Europe, where intensive agriculture prevails, are not entirely comparable with those in the United States, the Committee nevertheless considers that there is great scope for expansion in the use of agricultural aviation both in Western Europe, North Africa and other overseas territories. To put the matter on a sound international basis, it recommends the establishment of a European Agricultural Aviation Centre (possibly under the ægis of the Organization for European Economic Co-operation and the European Plant Protection Organization) and the formation of an association of agricultural air companies to facilitate the exchange of technical information, safeguard standards and promote research. In addition to describing the current uses of aircraft in agriculture in the United States, the report includes sections on the economic, technical and operational aspects of the subject.

Fusarium Studies

In a study of the antagonism of soil micro-organisms, including a considerable number of bacteria and actinomycetes, to *Fusarium oxysporum* f. *lini*, a pathogen causing wilt of cultivated flax, R-O. Lachance and C. Perrault (*Canad. J. Bot.*, **31**, 5, 515; 1953) found that nineteen bacteria and eleven actinomycetes showed some antagonism; of eleven organisms which yielded large inhibition zones on agar plates, six had a fungicidal and five a fungistatic action on the *Fusarium* conidia. Among the nineteen antagonistic bacteria under trial, six induced a swelling of the germ tubes or the production of an appressorium-like structure on agar. Greenhouse experiments have indicated that fifteen bacteria and eleven actinomycetes offered a certain protection to seedlings, some of which reached 6, 12, and sometimes 24 in. in height before showing any signs of wilting. The organisms evidently delayed the onset of wilt symptoms, but failed to protect the plants through their entire growth. R. H. Storer (*ibid.*, p. 693) has reported on the effect of soil moisture on *Fusarium* species. Six species and forms of the genus *Fusarium* show optimum growth and survival in soil at 15 per cent saturation. Optimum soil moisture content for actinomycete growth and survival is similar to that for the *Fusarium* species, whereas that for bacteria is at 75 per cent soil saturation. The present studies indicate that *Fusarium* spp. are strongly aerobic and that *Fusarium* populations can be greatly reduced by maintaining the soil in a saturated condition in the absence of hosts.

Salt-uptake by Root Tissue Cytoplasm

The relation between the uptake of salt by root tissue, that is, by the cytoplasm, and the external concentration of the salt, has been investigated in some of its biophysical aspects by A. B. Hope (*Austral. J. Biol. Sci.*, **6**, 396; 1953). The proportion of a given length of bean-root tissue which appears to reach the external concentration when placed in potassium chloride solutions (the apparent free space) increases as the external concentration is increased. The experimentally determined values of the apparent free space at various concentrations of the medium fit the curves representing the quantitative relations between apparent free space and the external concentration deduced by assuming a Donnan equilibrium between the root cell cytoplasm and the medium at each concentration. Thus the experiments indicate the presence of non-mobile ions (probably anions) in the cytoplasmic phase. The concentration of these ions has been calculated to be of the order of 0·01 mol./l. for both bean and maize root cytoplasm. Mature cells seem to have a higher concentration than those less mature. The relation between uptake of potassium chloride by bean-root sections and the time of immersion has been found to follow Fick's law of diffusion. The apparent coefficient of diffusion for potassium chloride in the tissue has been calculated. A typical figure is $0{\cdot}07 \times 10^{-5}$ cm.^{2} sec.$^{-1}$, about one-twentieth of the value for an aqueous solution for the same concentration. The results of these experiments are discussed in relation to the few existing evaluations by other investigators of the non-mobile ion content of cell cytoplasm.

Bibliography of Natural History

The Society for the Bibliography of Natural History (c/o The British Museum (Natural History), London, S.W.7) is a scientific society instituted for the study of the bibliography of all branches of zoology, botany and geology. The Society publishes a *Journal* containing collected lists of bibliographical papers already published on various branches of natural history; original contributions in regard to the dates of publication of zoological, geological and botanical works; particulars relating to the disposal of the libraries and collections of deceased naturalists; and papers on bibliographical subjects. It is proposed also to publish from time to time in the *Journal* facsimile reproductions of rare or unique works or parts of works on natural history.

Effect of Movement of Surface Masses on the Rotation of the Earth

In a paper on "The Effect of the Movement of Surface Masses on the Rotation of the Earth" (*Mon. Not. Roy. Astro. Soc., Geophys. Supp.*, **6**, 8; 1953), Andrew Young refers to the third edition of Sir Harold Jeffreys's "The Earth" (pp. 215–16), where doubt is expressed concerning the validity of the equations of motion governing the variation of latitude. This doubt arises from the view that an observer on the solid surface of the earth cannot observe the changing motion of the whole earth, because the axes fixed in the solid earth do not necessarily continue to coincide with the axes of reference

used in the derived equations. In addition, with the seasonal redistribution of surface masses which gives rise to the forced motion in the variation of latitude, there is associated a seasonal variation of angular momentum relative to the solid earth, and this is responsible for an observable variation in the rate of rotation. Mr. Young shows that in the investigation of the effect of surface mass movements on the general rotation of the earth, the change in the length of the day may be treated independently of the variation of latitude. In addition, the seasonal variation of latitude can be described by the usual equations, but account may have to be taken of corrections for the angular momentum of the surface masses. He derives equations which are based on the assumption of axes of reference fixed in the solid earth, and hence fixed relative to an observer on the solid earth, which disposes of the doubt expressed by Sir Harold. It is claimed that the equations remain valid for secular changes in mass distribution over periods of decades; but for periods of centuries some modifications in the equations may be necessary.

Geological Museum, London

The Geological Museum in South Kensington has now been opened to the public for ten years—four before the Second World War and six years since. It was thus appropriate that in the February number of the *Museums Journal* Mr. A. J. Butler, assistant curator, should give a brief critical commentary based on experience gained during these years. Attendance at the Museum has risen progressively since the end of the War. Though the Museum is visited by specialized groups of the community, it is estimated that about a quarter of a million went for divers casual reasons. The success of the regional policy in exhibition is now assured, while the geological globe, the gemstones exhibit and the illuminated geological column are always centres of attraction. Mr. Butler is definitely of the opinion that the well-known dioramas have fully justified their initial outlay. He feels, however, that although the exhibits are arranged on a systematic plan, few visitors follow this but wander from one point to another according to the object which happens to hold their fancy.

Index for 1921–50 of the *Physical Review*

The original intention of the American Physical Society was to publish a cumulative index to the *Physical Review* every tenth year; but this has never been realized. The first index covered the period from the first issue of the journal in 1893 to 1920. In 1930 the world depression, and in 1940 the Second World War, prevented further publications. However, with the financial assistance of the Office of Naval Research and under the direction of Prof. J. W. Buchta, a cumulative index covering the thirty-year period 1921–50 has now been compiled. It is published in two volumes, an author index of 543 pages and a subject index of 498 pages. Prof. Buchta is the present editor of the *Reviews of Modern Physics*; but during the period covered by the index he was assistant editor of the *Physical Review*.

Library Classifications

In a letter commenting upon Prof. Purchon's communication (see *Nature*, **172**, 940; 1953) on library classification, which he thinks expresses the disappointment felt by others with the Library of Congress Classification, and the Universal Decimal Classification, Mr. Faquir Chand, of the Department of Library Science, University of Delhi, directs attention to the Colon Classification invented by Prof. S. R. Ranganathan. Mr. Chand points out that during the past ten years Ranganathan and his co-workers in India and Great Britain have evolved several helpful concepts and techniques which have made such classification sufficiently resilient to accommodate new knowledge without disturbing the sequence among old knowledge. The fourth edition of Ranganathan's book "Colon Classification" was published by the Madras Library Association in 1952, and Mr. Chand states that a new quarterly periodical, *Annals of Library Science*, will be published to communicate the findings of the Library Research Circle at Delhi, which is constantly engaged in giving effect to the new concepts and in improving the new techniques.

Statistics and Personnel Management

A paper on "Statistics and Personnel Management" was given by Prof. M. G. Kendall at the national conference of the Institute of Personnel Management in Harrogate during October last year, and it has now been published by the Institute (Occasional Paper No. 3; pp. 16; London, 1953; 3*s*.). It is an unexpectedly sprightly and general account of the subject, for Prof. Kendall has managed in the space of sixteen pages to make clear, if not to define, the essential nature of the statistical method in social applications, to state Pareto's Law and apply it illustratively to a question of wage-fixing, and to indicate ways in which statistics might, and perhaps should, be used in other managerial problems. The pamphlet forms useful reading for sixth forms of schools or first-year economics students.

National Science Foundation: Grants

The award of a second group of grants during the fiscal year 1954 for the support of basic research and related matters has been announced by the National Science Foundation, Washington, D.C. The grants are a hundred in number and total about 1,045,000 dollars, their purpose being for research in the biological and the physical sciences, and for the support of studies and conferences on science, scientific information exchange, compilation of scientific personnel information, education in the sciences, and travel of American scientists to international scientific meetings. The awards for research are for work in the following fields: astronomy, chemistry, developmental biology, earth sciences, environmental biology, engineering sciences, mathematical sciences, molecular biology, physics, psychobiology, regulatory biology and systematic biology. Tenure of the grants ranges from one to five years, with an average length of 2·2 years.

Physical Society's Handbook of Scientific Instruments and Apparatus

The Physical Society's exhibition at the Imperial College of Science and Technology (Imperial Institute Road, London, S.W.7) is now a firmly established 'hardy annual' of London's scientific life, the recorded attendance last year being more than twenty thousand, and equally established and an essential requisite for all those who intend to visit the exhibition this year (to be held during April 8–13) is the Society's "Handbook of Scientific Instruments and Apparatus, 1954" (pp. 201+pp. 76 advertisements; from the Society, 1 Lowther Gardens, Prince

Consort Road, London, S.W.7; 6*s*., or 7*s*. 3*d*. by post). But the value of the handbook is not limited to those who will have an opportunity of seeing the exhibition, for within its two hundred-odd pages are to be found a selected account of British instruments and apparatus and scientific and technical books that will serve as a valuable reference work to all those concerned with the physical sciences and technology. The book is arranged in numerical order of stands at the exhibition, and short paragraphs describe each particular item. There are an index of exhibitors' names and a fairly detailed subject index which supply all that is needed to locate any entry. Because of the restriction of exhibition space this year, the Society has been forced to limit severely the number of firms and establishments which it could invite to participate, and in order to compensate for this in some measure a new section of the handbook has been instituted in which firms describe items that would have been exhibited had space been available; this section, which consists of twenty-nine pages, is printed on yellow paper to distinguish it from the other items.

University of London: Appointments

THE following have been appointed to readerships tenable at the Royal Free Hospital School of Medicine, University of London: Dr. D. N. Baron (chemical pathology), formerly senior lecturer in clinical biochemistry in the Middlesex Hospital Medical School, London; Dr. Eleanor J. Zaimis (pharmacology), formerly lecturer in pharmacology in the School of Pharmacy, London. Dr. P. Du Val, formerly senior lecturer in the University of Bristol, has been appointed to the University readership in geometry tenable at University College, London. The title of reader in mathematics in the University of London has been conferred on Mr. T. V. Davies in respect of the post held by him at King's College, London.

Atomic Energy of Canada, Ltd.: Chalk River

IN *Nature* of January 2, we referred to the Chalk River atomic energy establishment as "a closed community engaged exclusively on secret work". Dr. W. B. Lewis, Vice-President for Research and Development, writes that this is not the case. "Almost all research work at Chalk River in pure nuclear physics and in biology is non-secret and less than half of that in chemistry is secret. It is mainly the technological aspects of the plant which are secret. The scientific staff freely discuss their work with colleagues in universities and other laboratories in America and Europe. Some fifty papers on original work are published annually. Lectures are given at universities and scientific institutions by scientists on the staff, and papers are presented at meetings of learned societies such as the American Physical Society, the Royal Society of Canada and the Chemical Institute of Canada. Visitors from other laboratories may come to Chalk River for discussions of non-secret work, subject only to certain reasonable formalities. General interest visits are not encouraged, but visiting scientists number about forty a month. As in Britain, security clearance is a requirement for all staff, because the disadvantages of splitting the establishment far outweigh the possible advantages. Besides basic research, it should be noted that the principal target of Canada's atomic energy programme is atomic power. Although by British standards this plant is geographically remote, it is not, we feel, intellectually isolated."

Announcements

THE University of Sheffield has conferred the title of reader on the following: Dr. J. G. Boswell (plant physiology), at present senior lecturer in botany; and Dr. E. T. B. Francis (vertebrate zoology), at present senior lecturer in zoology.

DR. R. M. WILLIAMS has been appointed director of the Applied Mathematics Laboratory of the Department of Scientific and Industrial Research, New Zealand, in succession to Mr. I. D. Dick, who was recently appointed an assistant secretary of the Department. Dr. Williams was born in Christchurch, New Zealand, and graduated in mathematics from Canterbury College in 1940. After war work, first on radar and then in the United States on the atom bomb, he obtained a Ph.D. at Cambridge and then, in 1949, took up a post as senior mathematician at the Applied Mathematics Laboratory.

THE new building of the Borough Polytechnic, London, S.E.1, will be open for inspection during April 7–9. This building includes laboratories for pure and applied chemistry, biology and biochemistry.

As a result of war damage, etc., the records of University College, London, were much impaired. The College is now preparing a complete list of those who have studied there either as undergraduates or postgraduates or who have been otherwise associated with the academic work there. The College is therefore asking anyone who has been in any way associated with it to write to the Secretary, giving their present addresses and a short statement of their careers with dates.

THE seventh annual congress of the Laboratory Animals Bureau will be held this year in the University of Sheffield during April 5–6. At the end of the first day the Animal Technicians Association will hold its annual general meeting. Further information can be obtained from the Laboratory Animals Bureau, M.R.C. Laboratories, Holly Hill, London, N.W.3.

THE Universities Federation for Animal Welfare is holding an Easter congress in University College, London (Malet Street, London, W.C.1), during April 6–9. The congress is open to all, whether members of the Federation or not, on payment of a fee of 2*s*. 6*d*. Full board (£3 3*s*., or 30*s*. for students) is available in the College. Further information can be obtained from Miss M. P. Williams, Branch Organizer of UFAW, 284 Regent's Park Road, London, N.3.

THE Development Commission is offering a few grants to British honours graduates for training in research problems in marine or freshwater science, which is designed to fit them for employment either in the Fishery Research Services of the Ministry of Agriculture and Fisheries and the Scottish Home Department or in a marine or freshwater biological research institute. The grants are worth £250–£350 a year, with extra university fees paid, and are tenable from October 1 initially for one year, but renewable up to a maximum of three years. Application forms, to be returned by May 20, can be obtained from the Secretary, Development Commission, 6*a* Dean's Yard, Westminster, London, S.W.1.

NOMENCLATURE OF VIRUSES

THERE has been much discussion as to the wisdom of applying to viruses binomial names of the Linnæan type, and in particular as to the advisability of doing this over the whole field and forthwith. At the Fifth International Congress of Microbiology held in Rio de Janeiro in 1950, the International Nomenclature Committee, on the advice of its virus subcommittee, held that an attempt to apply binomials to viruses in a comprehensive way is premature; it suggested what criteria could be used in any attempted classification; further, study groups were set up for certain better-known virus groups with the view of determining whether binomials could profitably be applied to such viruses, as a beginning. Study groups were thus set up for the psittacosis–lymphogranuloma group (Chlamydozoaceae), the pox viruses, insect-pathogenic viruses, the viruses related to influenza and those of the arthropod-borne encephalitides.

At a symposium held in New York in January 1952, this piecemeal 'Rio approach' was generally favoured; and two more study groups were set up for viruses related to poliomyelitis and herpes simplex respectively.

At the Sixth International Congress of Microbiology held in Rome in September 1953, the virus subcommittee of the International Nomenclature Committee considered the whole question, having before it the reports of its study groups. Nine animal virologists and six plant virologists were present at one or both of the meetings held. They decided to reiterate the conclusions of the meeting in 1950 that at present "the use of systems of classification for and the application of binomials to viruses as a whole are undesirable and should be discouraged". They also recommended that the starting date for valid Linnæan nomenclature for viruses should not yet be determined, and that until this was done names for viruses already proposed should have no standing in bacteriological nomenclature.

The subcommittee favoured, with one dissentient, the application of internationally accepted names to all viruses. On the other hand, the plant and animal virologists present, polled separately, voted by majorities against the application of Linnæan binomials to viruses at the present time. The feeling of the majority was that such names necessarily carried implications as to taxonomic relationships, and that sufficient evidence as to such relationships was not yet available.

The animal virologists, at a separate meeting, felt that the use of comprehensive systems of nomenclature such as had been introduced in teaching as well as in the literature[1] would not be discontinued unless something else were offered as a substitute. Use of a Linnæan system at the moment would be particularly unfortunate if it led to an undesirable separation of practice between the animal and plant subsections. Other names were therefore put forward of such a nature that their special character was obvious, yet they could later be transferred to the Linnæan system under the International Code. Grouping of viruses should at present start at the generic level (or equivalent).

It was agreed that the report of the Chlamydozoaceae study group should be accepted; this held that the viruses related to psittacosis were closely related to the rickettsiæ and should be considered together with them. This implied their inclusion in Rickettsiales under the bacteriological code and their removal from the sphere of consideration of the virus subcommittee.

A majority vote favoured a uniform system of forming the equivalent of generic names, and rather than forming these from personal names (eponyms), favoured the use of the suffix '-virus' as shown in the appended list. Such a suffix would mark these names as being something apart from the Linnæan system but need not involve change in names if the Linnæan system were later applied to viruses. Names with the '-virus' suffix should be of the neuter gender. Though the names of viruses would be binomials, the terms 'genus' and 'species' would be avoided at present, the terms 'group' and 'group-member' or similar designation being used instead. Such names should, however, be printed in italics in scientific papers, as with Linnæan names, and capital letters would be used for group names. The names would not, however, be ascribed to authors, as under the Linnæan system, and the law of priority would not be applied at the present time. In order, therefore, to avoid confusion, the names under this system should be officially sanctioned by the International Nomenclature Committee or its virus subcommittee. The equivalent of type species should not be designated, but type strains should be deposited with appropriate collections of type cultures. Names in the appended list would be the first to receive such official sanction. The list of approved names of group members should be added to and revised from time to time. Publication of lists of newly approved names should be in the *International Bulletin of Bacteriological Nomenclature and Taxonomy*; but full descriptions of viruses the names of which were approved should be published in other appropriate scientific journals by specialists concerned, with the approval of the virus subcommittee.

The plant virologists, rejoining the discussions, concurred with the principles just outlined, though not committing themselves to the use of the '-virus' suffix or any particular form of 'group' name in their field. Dr. L. M. Black, chairman of the plant virus subsection of the virus subcommittee, was unable to be present; he had not been able to present a report likely to command any general acceptance among plant virologists. Dr. J. Craigie, for the bacteriophage subsection, had submitted a unanimous report which maintained that Linnæan binomials could not at present be suitably applied in the phage field. Of the animal virus study groups, that considering arthropod-borne encephalitides felt that relationships within the group were at present so uncertain that application of binomial nomenclature was premature. Names were agreed to for viruses of the pox, influenza, insect-pathogenic, poliomyelitis and herpes subgroups, based on reports of the various study groups and, in some instances, modified by the main virus subcommittee.

It appeared that plant virologists were much more evenly divided concerning the use of Linnæan binomials than were animal virologists. The use of the '-virus' suffix is proposed now only for animal

viruses. The subcommittee was strongly against any course of action which would prejudice future chances of a common policy for the nomenclature of all viruses, especially now that some viruses have been shown to multiply both in plants and insects. It thought that its recommendation embodied useful positive proposals for animal viruses, and yet did not compromise future parallel action with plant virologists.

A report embodying these conclusions was presented to the main International Nomenclature Committee, which approved its publication in the *International Bulletin of Bacteriological Nomenclature and Taxonomy*. This explanatory note is written in the belief that as wide publicity as possible for the recommendations is desirable.

PROPOSED 'NON-LINNÆAN' BINOMIALS FOR SOME ANIMAL VIRUSES

Poxvirus variolae	(smallpox)
" *officinale*	(vaccinia)
" *bovis*	(cow-pox)
" *muris*	(ectromelia, mouse-pox)
" *avium*	(fowlpox)
" *molluscі*	(molluscum contagiosum)
" *myxomatis*	(rabbit myxoma)
Herpesvirus hominis	(herpes simplex)
" *suis*	(pseudorabies)
" *simiae*	(B virus)
" *cuniculi*	(Virus III)
" *varicellae*	(varicella)
Poliovirus hominis	(human poliomyelitis)
" *muris*	(mouse encephalomyelitis, *TO* type)
Myxovirus influenzae-A	
" " *-B*	
" " *-C*	
" *pestis-galli*	(fowl plague)
" *multiformis*	(Newcastle disease)
" *parotitidis*	(mumps)

The group name *Myxovirus* for viruses related to influenza was intended to indicate that the viruses in question have a particular kind of affinity for certain mucins.

INSECT-PATHOGENIC VIRUSES

Polyhedrovirus (= *Borrelina*): group members are *P. bombycis, efficiens, reprimens, olethrium, campeoles, peremptor, fumiferanae.*
Capsulavirus (= *Bergoldia*): group members are *C. calyptum, daboium, latheticum, thompsonium, clistorhabdion, brassicae* and *nosodes.*
Globovirus (= *Smithia*) *rotundum.*
Moratorvirus (= *Morator*) *nudum.*

All the names of group members among insect pathogenic viruses correspond to the specific names listed by Bergold[2] and Steinhaus[3].

C. H. ANDREWES

(Chairman of the Virus Subcommittee, International Nomenclature Committee.)

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RADIATION HAZARDS OF ATOMIC ENERGY*

A POWER programme on which a nation's economy rests inevitably has its hazards. Coal-mining is a dangerous occupation; drilling for oil and refining is subject to fire risk. Releasing energy from the atomic nucleus has its own particular dangers, notably from ionizing radiation, and the atomic-energy industry of the future will have to be planned to avoid these hazards. The cost of safety devices will be great, and it will be the business of statesmen to decide how to balance the economic price of safety against the hazards to health.

Experience with ionizing radiations began more than fifty years ago with the discovery of X-rays and radioactivity. Many of the early investigators fell victim to burns, diseases of the blood and blood-forming organs, and cancer. In 1921 the X-ray and Radium Protection Committee was formed in Great Britain which set national standards of safety. This task has now been taken over by the International Committee on Radiological Protection.

Originally the safety of only a few hundred experimenters had to be considered; but now it is a problem of hundreds of thousands within the atomic-energy industry, and of the population at large. There are two main hazards to consider: those from electromagnetic and corpuscular radiations applied from without, and from radioactive materials taken into the organism.

Nuclear reactors must be enclosed within biological shields to absorb the γ-rays and neutrons. The re-processing of enfeebled reactor fuels and the extraction of plutonium and fission products must be carried out in a way which will minimize the escape of radioactive materials to the atmosphere or in drains. It is impossible, however, to prevent such escape completely and one must budget for a certain liberation of radioactive elements in routine operation, in addition to possible accidents. The question then is what is the radiation dose that can be tolerated.

All ionizing radiation is harmful to living tissue. Nevertheless, evolution has occurred in the presence of a natural background of radiation from cosmic and terrestrial sources, which produce a total dose of about 100 milli-roentgens per year. On the other hand, it is known that large doses have caused death and disease among scientific workers, luminous dial painters and miners in the Schneeberg; these effects can be reproduced by irradiating animals. In addition, radiation can induce unfavourable mutations. Little is known of the effects of radiation in human genetics and one has to infer from genetic investigations on the lower forms of life, where reproduction is rapid, such as the *Drosophila* or the mouse. The phenomenon of increased mutation-rates might be the limiting factor in the ultimate development of atomic power. What one can do at the moment, when still only a small fraction of the population is at risk, is to see that the national population dose of radiation released by man (the product of average dose of those occupationally exposed and the total number exposed) does not significantly exceed the national population dose from natural radiation. This is a form of compromise adopted in establishing the maximum permissible dose, which usually is about one-tenth of the minimum damaging dose to man or experimental animal. Where this is unknown it is calculated from biological or physical data and extra safety factors are added.

One of the main problems is the disposal of fission products. Some can be concentrated to a small volume and made insoluble in water and stored underground or under water until they decay. A small fraction, however, will inevitably escape into the air or into drains, preferably direct to the sea, where the activity will be greatly diluted. If the energy equivalent to the present total coal consumption in Great Britain were obtained from fission, the total activity of, say, strontium-90 would amount to

* Summary of a lecture by Dr. J. F. Loutit, being the fourth of the series of public lectures arranged by the Atomic Scientists' Association and the Department of Extra-Mural Studies of the University of London (see also *Nature*, February 27, p. 386, March 13, p. 477, and March 27, p. 573).

8,500 megacuries. If this were 1 per cent of the world's effluent and it all became uniformly mixed in the sea (of a total volume $1{\cdot}4 \times 10^{24}$ c.c.), the concentration would be 6×10^{-7} microcuries per c.c., which is about the permissible activity for drinking water. The sea already contains 3×10^{6} megacuries in the form of radioactive potassium, hence there should be no danger if the active effluent is uniformly mixed. Unfortunately, mixing in the sea is subject to weather conditions and there may be 'hot' spots of dangerous activity.

The biological hazards from the fission products depend largely on their chemical and physical states. Iodine, for example, is very important biologically because of its concentration in the thyroid; but it is not a serious problem in routine operations as it decays in a short time. In accidents or bombs, however, it may become a danger if it is deposited in the fall-out. In the Monte Bello test the fall-out contained water-soluble iodine, which was taken up in the thyroid of guinea pigs.

Of the other fission products, cæsium behaves like sodium; it is difficult to precipitate and would be expected to be found in water effluent. Tests for its presence in seaweed are being carried out. Barium and strontium, which are relatively soluble, are deposited in bone. The other elements are relatively insoluble in water or the digestive tract, but may be deposited on the lining of the gut.

The activity ingested by domestic animals is also of importance. The fresh vegetable diet consumed by man is small and its radioactivity has a chance to decay in storage. Animals, however, eat large quantities of grass, and superficial contamination of the earth presents an internal hazard to the animal and, consequently, to man eating the meat. The safeguard is again the time factor, and that most of the activity is deposited in bone.

Man receives a relatively larger intake through the lungs than through the alimentary tract. Most of the particles are, however, large enough to be caught up in the filter system of the upper respiratory tract, from which they are finally conveyed to the gut. The most important thing, therefore, is to keep the air clean and uncontaminated. Clean air ensures clean soil, vegetation and water supplies. Use of the sea as a disposal ground must be controlled to avoid contamination of edible fish. The ocean deeps may be a suitable dump for concentrated sources until technical improvements in propulsion make it possible to discharge them to interplanetary space.

UNESCO ADVISORY COMMITTEE ON ARID ZONE RESEARCH

SESSION IN MONTPELLIER

THE Advisory Committee on Arid Zone Research, which is a Committee of the United Nations Educational, Scientific and Cultural Organization, held its sixth session in Montpellier during November 3–6, 1953, and the following are the principal recommendations that were made to the Director-General of Unesco.

Symposia. The holding of symposia should be continued, and, when possible, half of them should be jointly organized with other relevant agencies or scientific organizations so as to achieve closer liaison with them. The Director-General, it is suggested, should accept the invitation of the Indian Government to hold a symposium on "Wind and Solar Energy in Arid Areas" this autumn. Also, the subject for the symposium to be held in 1956 should be the formation and erosion of soils as affected by climatic factors, and this should, if possible, be held jointly with the Food and Agriculture Organization and the World Health Organization.

Review reports. It was decided at the session that review reports should be fewer in number and that they should deal with research subjects rather than consist of surveys of specific geographical areas. Each report ought to be a critical appreciation of work done and not merely a summary of publications. The reports should be published in book form, and, when a symposium is held on the same subject, they should be published, if possible, with its proceedings. The recommendation was made that six reports be obtained dealing with human and animal ecology in arid regions, two being on human ecology and one each on the ecology of mammals, birds, locusts and other insects.

Arid zone fellowships. Candidates selected for such fellowships should be of sufficient seniority and training to obtain adequate benefit, and careful consideration must be given not only as to the best location for the Fellow to work but also as to the person responsible for his studies and the length of his stay in each locality. Each Fellow should submit both interim and final reports on his work to the Committee.

Research projects. The Committee recommended the following procedure to be adopted in the submission of research projects to Unesco, and for their consideration by the Committee. (1) Projects should be submitted after examination by, and with the support of, the national commission of the member State from which it originates. Information should be provided about the suitability of the applicant to conduct or supervise the work, and where relevant as to the relation of the project to other research. If the applicant is a member of a scientific institute, this institute should also give its support. (2) If it feels this desirable, Unesco should obtain further expert advice on the project from among its honorary consultants prior to submitting the proposal to the Advisory Committee. (3) Recipients of Unesco research grants must submit by March 1 and September 1 progress reports for the information of the Advisory Committee. Failure to submit such reports may involve the discontinuance of Unesco support. (4) The Advisory Committee should review current projects and should consider whether to advise continued support for them, before giving advice on the support of new projects.

The Committee also recommended that three criteria should guide the acceptance of projects submitted: the project must directly relate to a specific arid zone problem; it should bear on some principle of general scientific interest; and it should either be of a nature that can be expected to yield results within a period of two years, or be one that can be continued by local support, after initial financial aid from Unesco.

Unesco Symposium of Plant Ecology of the Arid Zone. Following the session of the Committee, a symposium organized by Unesco as part of its arid

zone programme was held during November 7–10 in Montpellier with the help and support of the university there. Speakers from fifteen countries contributed papers under the following sections. (*A*) Structural and physiological features of the vegetation. This section included papers on ecological classification, the fodder value of desert plants in South Africa, and the effects of land management on arid zone vegetation. (*B*) Climatic, ecoclimatic and hydrological effects on vegetation. The papers in this section dealt not only with effects of rain and other climatic factors but also with dew measurement and with forests in arid areas. (*C*) Soil and vegetation. This section covered the effects of soil type, the influence of minor elements and soil microbiology. (*D*) Influence of other factors. These included overgrazing and soil insects, and a valuable account was given of methods used in Australia in land-use surveys. The symposium as a whole included a number of valuable papers and provoked keen discussion. Its proceedings will be published.

NEW CHEMICAL LABORATORIES OF THE UNIVERSITY OF SHEFFIELD

THE new chemical laboratories of the University of Sheffield were opened on February 5 by the Earl of Scarbrough, and afterwards honorary degrees were conferred upon Sir Cyril N. Hinshelwood, Prof. C. K. Ingold and Mr. T. A. McKenna. A single structure now takes the place of laboratories that were formerly separated from one another and from the central stores by a hundred yards horizontally and as many feet vertically in a building without lifts. While the greater part of the cost has been met by grants to the University for that purpose by the University Grants Committee, the Staveley Coal and Iron and the Staveley Iron and Chemical Companies, in response to the appeal for a University Development Fund in 1947, covenanted to contribute a sum of £50,000 primarily for the benefit of the Chemistry Department. In permanent record of the University's appreciation, the research laboratories in the new Department have been named the Staveley Laboratories.

As the first stage of a larger structure which will be necessary for any significant increase in the present number of students, it consists of a main block facing Brook Hill, with a wing at its eastern end receding obliquely from the street. Provision has been made for additions when necessary at both ends of the block. The four-story building is of steel-framed brick faced with Portland stone; the sloping site allows unrestricted natural lighting to the lowest floor of the wing. The wing consists essentially of four large teaching laboratories, one above the other. From the lowest floor upwards, they are for intermediate classes, advanced inorganic chemistry, physical chemistry and elementary organic chemistry, respectively; each is served by a subsstore connected to the main store by a goods lift. These teaching laboratories have small rooms attached for special purposes, and in addition there are eight research laboratories and seven small rooms for lecturers.

The various floors are united by staircases at each end of the main block and an emergency staircase at the far end of the wing. There is a passenger lift at the junction of the main block and the wing, and provision has been made for another lift at the west end. The junction of the wing and main block, with

New Chemical Laboratories of the University of Sheffield

its lifts and staircase, thus constitutes the main distributory channel for the whole building.

On the lower ground floor of the main block are the central stores, with goods entrance and unpacking area, and separate accommodation for dangerous or excisable materials; here also are the mechanics' workshop, glass-blowers' room, analytical preparation room and micro-analytical laboratory, a laboratory for heavier equipment, and the electrical sub-station and calorifiers serving the building. A basement provides further storage facilities, a constant-temperature room, refrigeration room, and rooms for special equipment.

The main entrance is to the ground floor, which has common-rooms for teaching and laboratory staff and for research students, cloak-rooms, X-ray and spectroscopic laboratories, and the main lecture theatre, which seats 250. This theatre, more than large enough for present departmental needs, is intended to be used also for general university purposes. At the very fully equipped lecture bench are controls governing the window blinds (in sections), the room lighting (in sections), blackboard movement and lighting, and spotlighting of the bench itself. The projection box, in communication with the bench, has 35-mm. and 16-mm. projectors, microfilm projector, lantern and epidiascope.

The Wynne Library, built out from the western end of the ground floor, has been equipped with steel shelving calculated to cope with the menacing expansion of chemical literature for some ten years. It is named in commemoration of the great services to the University of the third professor of chemistry, the late William Palmer Wynne.

Whereas in the completed building the first floor will be entirely devoted to physical chemistry, three of the seven research laboratories in the main block are at present used for organic chemical research. There are also on this floor a reader's room, dark rooms and other small rooms for special purposes, and a lecture theatre with seating for 120. On the second floor of the main block are the professor's room, a reader's room, lecturer's room, four research laboratories, small rooms for special work, a teaching laboratory for advanced organic chemistry, and a small lecture theatre seating 60. Rooms for solvent recovery and for conducting dangerous operations are provided on the extensive flat roof.

As a whole, the building provides working places for some 240 undergraduates at any one time, and, including the teaching staff, for 50–60 research workers. Accommodation for the more elementary classes is multiplied by duplication or triplication of lockers, so that places can be found for as many as 450 undergraduates.

The services in the laboratories include high- and low-pressure cold water, hot water, gas, electricity, steam and compressed air, all carried in readily accessible channels 10 ft. apart, running vertically and horizontally. In addition to the ordinary a.c. supply at 240 V., three-phase current is available at certain points, and d.c. supply is from mobile rectifiers and batteries. Lighting is in general by tungsten lamps in corridors and lecture theatres, but by fluorescent strip, sometimes of 'colour-matching' type, in teaching and research laboratories. Ventilation is by window and by extractor fans—one for each fume cupboard—which work from the roof. The building is heated by hot water provided from the main University station across Winter Street, operating through panels in the walls.

AN ATLAS OF END-GRAIN PHOTOMICROGRAPHS FOR THE IDENTIFICATION OF HARDWOODS

As the number of hardwood timbers from tropical countries now being placed on the market increases, their identification has become increasingly difficult. The Forest Products Research Laboratory, Princes Risborough, has already produced Bulletin No. 25, "Identification of Hardwoods: A Lens Key", which provides a practical method of timber identification for those lacking laboratory facilities—in other words, for the man out in the forest or in the timber yard. It may not be generally known that, among tropical timbers at least, there may be a close resemblance between a timber of considerable value for structural and other purposes, for example, and another, or more than one, which is of an inferior quality. The fact that the latter exists in greater abundance in the forests and therefore is of easier and cheaper extraction can lead to substitutions which are far from desirable.

The "Lens Key" was prepared for the use of the practical man engaged in the extraction and marketing of these more or less new tropical timbers. To indicate its value to the forest man, an illustration may be given. Whenever possible, water transit is the cheapest and easiest for the transport of heavy timber materials. The felled trees after topping are made up into great rafts and floated down the river until they reach the port or checking station. One or more of the rafts may purport to be of the valuable species of timber of the region. Yet it is simple to include a number of logs of the inferior species, the whole raft being passed for payment on the higher royalty scale. Armed with the "Lens Key", the checking officer is in a position to stop this kind of thing.

The Forest Products Research Laboratory has now produced an addition to the "Lens Key" which can be used in conjunction with it. Bulletin No. 26, entitled "An Atlas of End-Grain Photomicrographs for the Identification of Hardwoods"*, supplements the "Lens Key" by providing photomicrographs of the timbers dealt with in the latter and enables users to verify their identifications by comparison with photographs of authentic species. As the author says: "it provides a ready means of checking that a timber is what it is reputed to be". Of course, it is to be understood that the user of the "Atlas" must be able to prepare a cleanly cut end-grain surface of the timber in question. A safety-razor blade can be used for the purpose, as it gives a sharper and cleaner cut than a knife.

There are 396 photomicrographs, all beautifully clear reproductions, in the "Atlas" at a × 10 magnification which shows the structure of the timbers dealt with. The arrangement of the photomicrographs according to alphabetical order of botanical families, and within each family similarly according to the botanical names of the timber, is exactly parallel with that adopted for the descriptions of the timbers in Bulletin No. 25. An index giving botanical and common names of the timbers is appended.

* Department of Scientific and Industrial Research. Forest Products Research Bulletin No. 26: An Atlas of End-Grain Photomicrographs for the Identification of Hardwoods. Pp. iv+87. (London: H.M.S.O., 1953.) 12*s.* 6*d.* net.

KODAIKANAL OBSERVATORY

ANNUAL REPORTS FOR 1951 AND 1952

THE annual reports of the Kodaikanal Observatory for the years 1951 and 1952*, both of which have only recently been received, deal mainly with the astronomical work of the Observatory; the meteorological data appear in the *India Weather Review* and the administrative details are to be incorporated in the annual report of the India Meteorological Department. The golden jubilee of the Observatory was celebrated in September 1951, and the event was marked by the inauguration of the newly built Ionospheric Laboratory and of the newly installed 'Bhavnagar Telescope', a 20-in. Cassegrain reflector constructed by Grubb which originally belonged to the now defunct Poona Observatory and named after Maharajah Takhtasinghji of Bhavnagar.

An expedition was organized to observe the total eclipse of the sun on February 25, 1952, and the party of four, led by Dr. A. K. Das, started on December 27, 1951, for the eclipse camp at Ar Ratawi in Iraq. On this expedition, which is referred to in the 1952 report, the observational programme was unfortunately frustrated by bad weather at the time of the eclipse.

International co-operation, including the exchange of spectroheliograms and photoheliograms with foreign observatories, was maintained as usual (a list of these observatories is given); and the daily broadcasts of 'ursigrammes' relating to solar activity, and to issuing warnings for expected ionospheric and geomagnetic disturbances whenever expected, were continued.

A list of the equipment of the Observatory is given in each report, including (*a*) astronomical and spectroscopic instruments, (*b*) magnetic instruments, (*c*) electronic instruments, (*d*) workshop machinery, and (*e*) other instruments, with the names of the different instruments in use. The 1952 list shows one more under (*a*), one more under (*b*) and six more under (*c*) compared with the 1951 list. Weather conditions during 1951 were better than those of the previous year, and those of 1952 were better than the 1951 conditions. There was a considerable decrease in sunspot activity in both years. The number of prominences in 1951 showed a decrease of 15 per cent compared with the number in 1950, but there was an increase in the areas of 7 per cent; this was due to greater prominence activity during the second half of 1951. In 1952, prominence activity as represented by areas showed a decrease of 16 per cent, and the numbers an increase of 23 per cent over the 1951 results.

* Kodaikanal Observatory. Annual Report for the Year 1951; pp. 10, 1952; R. 1 or 1*s.* 6*d.* Annual Report for the Year 1952; pp. 12, 1953; As. 12 or 1*s.* (Delhi: Manager of Publications.)

PREHISTORIC SETTLEMENT PATTERNS IN THE VIRÚ VALLEY, PERU

THE Virú Valley Project was an intensive survey of one of the smaller irrigated valleys of the Peruvian coast. It was mainly archæological, but embraced also cultural geography and a study of the modern population, and it was carried out by a number of teams from different North American institutions with the co-operation of Peruvian scholars. Each institution supported its own team and is publishing the results, but they worked together and shared certain resources supplied by the Viking Fund of New York. The work was done in 1946, when Prof. G. R. Willey was working for the Bureau of American Ethnology. Although publication has been long delayed, some of Prof. Willey's views have influenced publication by his colleagues, so they have not been altogether hidden from students of the subject. Now that his conclusions are published in full as a Bulletin of the Bureau of American Ethnology*, his work forms an exceedingly valuable and interesting contribution to archæology.

The work is based on what must have been a very strenuous survey of the visible settlement sites in the valley, and descriptions of them, with plans, form a large part of the book. Each of the descriptive sections begins with a summary of the contents, so that the bulk of them need be used for reference only. They are preceded by introductory chapters which define the problem and describe the valley, and are followed first by a summary with conclusions about the actual settlement patterns, and then by a discussion of what can be learned from them about the population and its organization at different stages. Finally, these data are related to what is known of Peru as a whole. The plates, grouped at the end, are a useful addition, but the reproduction of some of them is a trifle 'woolly'.

Among the several useful publications resulting from the Virú Valley Project, this deserves a prominent place. By his fresh and thoughtful approach to his subject, Prof. Willey has made a notable contribution to our understanding of the ancient peoples of Peru. The organizers of the Project were fortunate in being able to select a unit of manageable size to deal with, and one which was sufficiently self-contained to make it possible to observe the effects of outside influences and invasions. Very useful results might be obtained if it were possible to follow their example in other centres of ancient civilization.

G. H. S. BUSHNELL

* Smithsonian Institution. Bureau of American Ethnology, Bulletin 155: Prehistoric Settlement Patterns in the Virú Valley, Peru. By Gordon R. Willey. Pp. xxii+453+60 plates. (Washington: Govt. Printing Office, 1953.) 4 dollars.

PHOTOLYSIS OF POLY METHYL VINYL KETONE: FORMATION OF BLOCK POLYMERS

By J. E. GUILLET and PROF. R. G. W. NORRISH, F.R.S.

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THE primary photolysis of aliphatic ketones, both in the gas phase and in solution, has been shown to occur by two simultaneous reactions[1]:

Type I, in which two free radicals are formed:

$$R.CO.R' \xrightarrow{h\nu} R. + R'CO. \rightarrow R. + R'. + CO$$

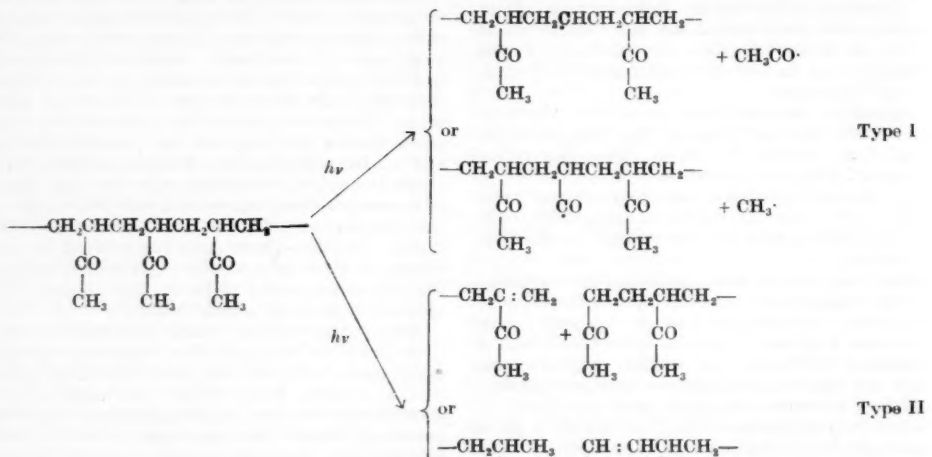
Type II, in which the molecules can split in the α–β position to the carbonyl group to give an olefin and a lower ketone, without the formation of free radicals; for example:

$$RCH_2CH_2CH_2COR' \xrightarrow{h\nu} RCH : CH_2 + CH_3COR$$

As the temperature is raised from 0° to 100° C., the acetyl radical formed in the first reaction becomes increasingly unstable and decomposes to give a free alkyl radical and carbon monoxide.

The Type I reaction has been used as a source of free radicals for the initiation of vinyl polymerization. For example, acetone has been used as a photosensitizer in the polymerization of a number of vinyl monomers[2].

As an extension to this early work, it occurred to us that vinyl polymers containing a carbonyl group would be expected to undergo similar reactions upon irradiation. For example, with poly methyl vinyl ketone, we should expect, schematically :



Both these predictions have been verified. The polymer shows a strong absorption band with its peak at 2900 A. due to the carbonyl group. Irradiation of solutions in dioxan by light of 3130 A. caused rapid reaction.

The occurrence of Type I reaction is demonstrated by the formation of carbon monoxide and methane when the reaction is carried out at 80° C., and the fact that aldehyde is formed due to the hydrogenation of the acyl radicals by the solvent.

That Type II reaction occurs as a split in the chain at the bond α–β to the carbonyl group is shown both by a rapid fall of molecular weight, and by the development of the absorption band beginning at 2300 A., characteristic of the conjugation of the double bond with the ketone carbonyl.

The quantum yield of the Type I reaction is of the order of 0·01, as measured by the rate of formation of carbon monoxide at 80° C., but this must be a lower limit in view of the formation of aldehyde mentioned above.

The occurrence of Type I reaction with poly methyl vinyl ketone, in which free bonds are formed in the polymer chain, immediately suggests the possibility of forming block polymers in which a long chain of one type is grafted to another long chain of a different chemical species.

In order to investigate this possibility, poly methyl vinyl ketone was photolysed in the presence of acrylonitrile monomer. The optical system consisted of a high-pressure mercury lamp (Siemens Type *ME*) mounted in front of a large searchlight mirror to give a concentrated beam of light. This was directed on to the reaction cell by two 30-mm. diameter diaphragms 15 cm. apart, using a water-cooled filter composed of 2·0 cm. of a solution containing 150 gm./l. $CoSO_4.7H_2O$ and 500 gm./l. $NiSO_4.7H_2O$, followed by 4 cm. of a solution containing 2·0 gm./l. potassium hydrogen phthalate to isolate the radiation of 3130 A. Operating at 1,000 watts, this light system gave an energy flux of $1{\cdot}1 \times 10^{-3}$ einsteins an hour across an area of 7·0 sq. cm. as determined by a uranyl oxalate actinometer. The reaction cell was of quartz, 2·0 cm. in length and 3·8 cm. in diameter; it was attached by a side arm to a bulb which could be used for freezing and degassing the solutions, and could be connected to a high-vacuum line through a tap and ground joint. Poly methyl vinyl ketone was prepared by polymerization of the pure monomer in dioxan solution, using benzoyl peroxide as catalyst; it was isolated by precipitation with diethyl ether, and washed with ether to remove any residual catalyst. It was then re-dissolved in dioxan and isolated by freezing with subsequent removal of the solvent by sublimation under vacuum. Osmotic pressure measurements in methyl ethyl ketone solution gave a molecular weight of 220,000.

Acrylonitrile was purified by distillation over ferrous sulphate in a stream of nitrogen, and stored until use in a flask cooled with 'dry ice' – acetone mixture; it was then introduced into the reaction cell using a standard volume in the high-vacuum system.

The ultra-violet absorption spectra of the various reagents are shown in Fig. 1. It will be seen that, using monochromatic radiation of 3130 A., we are working well within the absorption band of poly methyl vinyl ketone, but outside the absorption limit of solvent and acrylonitrile monomer, which latter cannot, therefore, be contributing to any primary chemical reaction. A preliminary series of experiments in dioxan solution showed that the rate of decrease of intrinsic viscosity was measurably less when the degradation was carried out in the presence

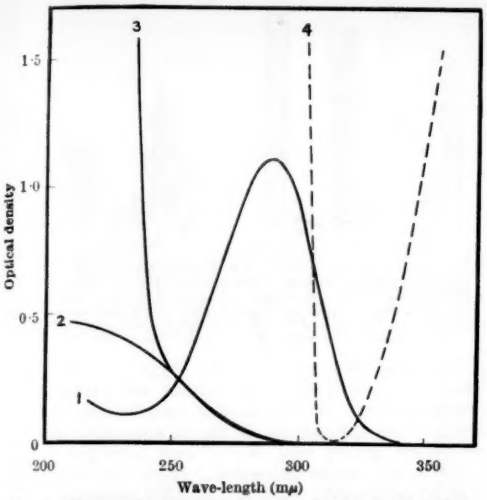


Fig. 1. Ultra-violet absorption spectra. 1, Poly (methyl vinyl ketone), 2·0 g.p.l. in dioxan; 2, dioxan; 3, acrylonitrile (monomer); 4, filters (combined)

of 4·5 gm./l. acrylonitrile monomer. There was, however, no sign of precipitated polymer even after several hours. If block polymers are formed in this case, it seems probable that the length of the acrylonitrile chains is not sufficient to cause precipitation.

A trial was then made in which 0·200 gm. of poly methyl vinyl ketone was dissolved in 20 ml. pure acrylonitrile monomer. On irradiation there was an immediate appearance of turbidity, and after 4·0 min. a solid precipitate had formed. This polymer was isolated by freezing, the residual monomer being removed by sublimation under vacuum. A Dumas analysis of the polymer showed it to contain 14·1 per cent nitrogen, which corresponds to 54 per cent acrylonitrile. An identical run in the absence of poly methyl vinyl ketone gave no evidence of polymer formation on irradiation for periods up to 30 min. The intrinsic viscosity of this polymer in dimethyl formamide was 3·3. Using the relationship reported by Houtz[3] for poly acrylonitrile in this solvent, the molecular weight was calculated to be of the order of 100,000. This corresponds quite well with the molecular weight which would be expected if two poly acrylonitrile chains were formed for each molecule of carbon monoxide formed by the Type I reaction, and allowing for partial depolymerization of poly methyl vinyl ketone by Type II reaction.

The polymer was qualitatively fractionated into three distinct components by the slow addition of dioxan to a 1 per cent solution of the polymer in dimethyl formamide. One fraction, which was precipitated almost immediately, appeared to be largely poly acrylonitrile. A second fraction was obtained which was soluble in mixtures of dioxan and dimethyl formamide containing at least 5 per cent of the latter component but was insoluble in pure dioxan. A third fraction, completely soluble in dioxan, corresponded to the usual degradation product of poly methyl vinyl ketone. It seems likely that the second fraction, which amounts to about a third of the total polymer and contains 75 per cent acrylonitrile, represents the major part of the block polymer formed.

In order to prove that the polymerization of the acrylonitrile monomer was not due to catalyst residues present in the polymer, a sample of pure methyl vinyl ketone was allowed to polymerize at room temperature, in the absence of any catalyst. After several days, about 10 per cent polymerization had taken place. This polymer was isolated by freezing in dioxan in the usual way, and 0·080 gm. was dissolved in 20·0 ml. acrylonitrile monomer and irradiated for 3·0 min. The reaction was immediate, yielding 0·235 gm. of polymer of intrinsic viscosity 4·3 ($\overline{M}_V \doteq 140{,}000$). Irradiation of pure acrylonitrile monomer in the absence of poly methyl vinyl ketone gave less than 0·002 gm. polymer. There was no dark reaction at room temperature in either case.

On the basis of these results, it would appear that in the photolysis of poly methyl vinyl ketone free radicals are formed which are capable of initiating the polymerization of acrylonitrile monomer. It seems likely that this leads to the formation of two additional polymeric species—pure poly acrylonitrile initiated by the free methyl radical (or acetyl radical) and a block polymer from the radical formed on the poly methyl vinyl ketone chain.

It is possible that this photochemical method may have further applications in the synthesis of other block polymers. [Jan. 13.

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GENETICS OF VIRULENCE IN INFLUENZA VIRUSES

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VIRULENCE of a virus or other pathogenic micro-organism may be defined as the capacity to produce lesions or symptoms in a given tissue or host. It is a quantitative, rather than an all-or-nothing, characteristic, and in practice it can only be assessed in terms of the difference in the response of two or more host animals or tissues which receive the same dose of virus, or of the difference resulting in the same host from the introduction of the same dose of two or more different viruses. The fact that influenza viruses of widely different virulence for the mouse can all be readily grown in the chick embryo and, with some necessary reservations, accurately titrated by hæmagglutination, makes viruses of this group particularly well suited for studies of virulence. We have been concerned for some time with an effort to analyse the behaviour of virulence when recombination between different virus strains takes place. In several instances the distribution of virulence among the progeny from a 'cross' between highly virulent and non-virulent strains indicates that there are multiple genetic factors involved. This may provide a new approach to the general problem of virulence in animal viruses.

In all of our work we have used the allantoic cavity of the chick embryo for culture and titration

of strains of influenza virus which possessed characteristic degrees of virulence for some other host or tissue. The earliest experiments were concerned with 'neurotropism'—the capacity of a strain to produce fatal encephalitis on intracerebral inoculation in mice. Subsequent recombination experiments were concerned with strains differing in virulence for the chick embryo as judged by the production of hæmorrhagic lesions, or for the mouse lung where the criterion is the extent to which the lung is consolidated seven days after a standard intranasal inoculation. Any influenza *A* virus isolated from a human infection by chick embryo inoculation and adapted to grow freely in the allantoic cavity lacks all three of these types of virulence. In each case strains of high virulence have had to be obtained by continued passage in the appropriate experimental host. Almost any strain can be adapted to produce gross lung lesions in mice; but only two influenza *A* viruses have given rise to variants capable of producing hæmorrhagic lesions in the chick embryo and/or transmissible fatal encephalitis in mice. These are *WS* (England 1933) and *MEL* (Melbourne 1935).

The general experimental method was to produce double infections with two strains which, in addition to dissimilar virulence, had other 'marker' characters that could be used to differentiate them. The product of these double infections was titrated in chick embryos and then re-titrated to obtain a sufficient number of positive fluids at the limiting infective dilution (*LD* fluids). These were then tested for each of the relevant characters. Representative examples of any recombinant types obtained were re-titrated and a second generation of *LD* fluids tested for uniformity of character.

Neuropathogenicity for the Mouse

In the work carried out by Burnet and Lind[1], and by Burnet and Edney[2], double infections with the neurotropic strain *NWS* and the standard influenza *A* strain *MEL* were made in the mouse brain. From these mouse brains, viruses were isolated which were *MEL* serologically but had the capacity to induce fatal encephalitis on intracerebral injection in mice. Such strains had an additional character not found with *MEL* in being convertible to the 'indicator phase' by simple heating at 55°. This character is easily checked *in vitro* by testing whether or not the heated virus is inhibited by high dilutions of a suitable mucoid inhibitor. For convenience all fluids were screened for the two *in vitro* characters, serology and convertibility to indicator, those which conformed to the pattern of neurotropic *MEL* strains being called *NM*'s. It was soon found, as noted by Burnet and Edney[2], that considerable numbers of *NM* strains were of much lower pathogenicity for the mouse than expected. In Fig. 1 are shown the results of a survey of experimental results obtained during Burnet and Edney's work in 1951. For this it was convenient to use the day of death of a mouse inoculated intracerebrally as an index of virulence. The 34 per cent of 257 mice inoculated with *NM* strains which survived fourteen days includes mice which showed definite symptoms around six days and then recovered completely, and a few—nearly all from groups in which most of the other mice died—which were sick and emaciated at the end of the test period. Others comprising about a third are from groups in which none of the mice showed any symptoms.

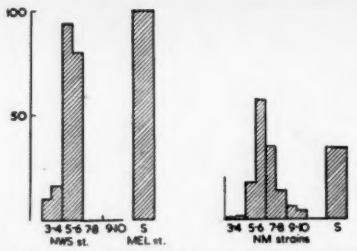

Fig. 1. Distribution of times of death from intracerebral inoculation of a standard dose of influenza virus strains. Area in each shaded bar shows percentage of inoculated mice giving the indicated result. 3, 4, etc., death on day shown after inoculation; *S*, survived 14 days. *NWS St.* + *MEL st*, stock viruses by the interaction of which *NM* recombinant strains were obtained

This has been the general type of experience whenever neuropathogenic strains are produced by recombination. A very similar distribution has been found when interaction of the strains *NM* (actively neuropathogenic) and *WS*− (non-pathogenic) took place in the allantoic cavity. Here the commonest type of progeny to show the *in vitro* qualities typical of the neurotropic recombinant which we refer to as *N–WSE* was only weakly encephalitogenic. Relatively severe symptoms were produced around the fifth to seventh day after inoculation of the standard dose of a fifth of one hæmagglutinating unit, but nearly all symptoms had vanished by the fourteenth day. Other fluids of *N–WSE* character *in vitro* produced fatal encephalitis, while some gave no symptoms.

Pathogenicity for the Chick Embryo with Hæmorrhagic Lesions

In the course of many experiments with the systems *MEL*/*WSE* and the primary recombinants *M*+/*WS*−[3–5], records were made of the embryo pathogenicity of large numbers of each *in vitro* type. In Fig. 2 the results are depicted in terms of the percentage of inoculated embryos showing lesions of each of four arbitrarily graded levels of severity.

It will be seen that *MEL*, neither as stock nor as experimentally produced recombinant, ever showed any hæmorrhagic power; *WS*− showed a very small proportion of embryos with some lesions. Experimentally obtained *WSE* strains show a wider scatter of activity and a lower mean pathogenicity than stock strains. Recombinant *M*+ strains show a similar wide range and include a number in the first bracket which represents failure to produce any

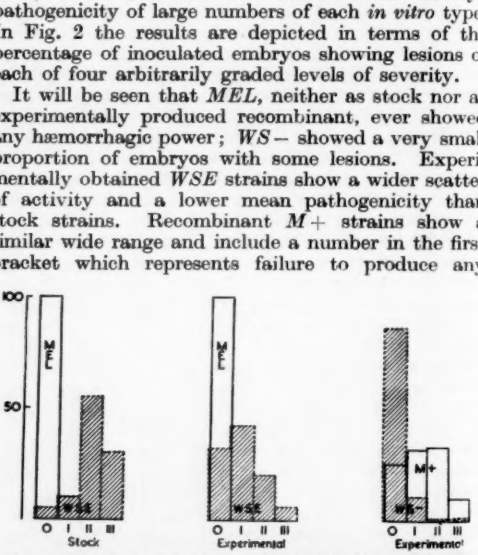

Fig. 2. Distribution of pathogenicity for the chick embryo in original and recombinant strains. Grades 0, I, II, III represent increasing intensity of hæmorrhagic lesions in chick embryos inoculated on the chorio-allantois. 'Experimental' fluids are pure clones derived from experiments in which recombination occurred, but include fluids of the same type as the parent forms as well as frank recombinants

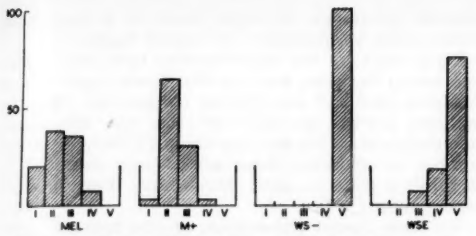

Fig. 3. Distribution of mouse-lung pathogenicity among recombinant types from influenza *A* strains. I–V represent increasing grades of average lung consolidation after administration of a standard dose (1 hæmagglutinin unit). The characteristic high virulence of *WS* strains and relatively low and variable virulence of *MEL* strains are unaltered by any of the manipulations

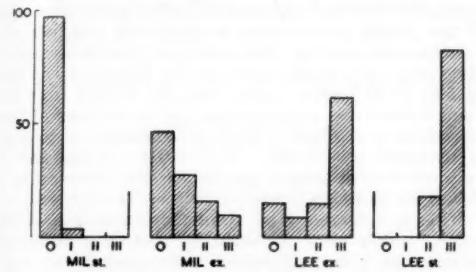

Fig. 4. Distribution of mouse-lung pathogenicity among recombinant types of influenza *B*. 0–III represent increasing grades of lung consolidation. Distribution of stock virus (*st*) clones and of clones from recombination experiments (*ex*) showing the range of pathogenicity associated with each serological type

hæmorrhagic lesions. It should be stated, however, that all *NM* strains which were tested in six or more embryos have produced some hæmorrhagic lesions in at least one embryo.

Mouse Lung Pathogenicity

When *MEL* is 'crossed' with the much more pathogenic *WSE*, the recombinants have the same grade of mouse-lung pathogenicity as corresponds to their serological type—*MEL* relatively low and variable, *WS* high and rarely failing to kill all mice inoculated. No differences could be seen between stock and recombinant types, and in Fig. 3 are shown histograms for the four types as obtained from *MEL*/*WSE* or *M*+/*WS*− experiments[3–5]. It is particularly striking that *WS*− recombinants from *MEL*/*WSE* experiments showed none with any reduction of mouse-lung pathogenicity, nor is there any evidence that *M*+ strains deviate significantly from the *MEL* pattern.

With experiments on the influenza *B* strains *LEE* and *MIL*, the pattern of relatively free distribution of virulence among the recombinants is seen again[6]. *MIL* has no lesion-producing power in the standard dose; *LEE* averages 3+ lesions. In Fig. 4 is shown the distribution of mouse-lung pathogenicity for stock *LEE* and *MIL* strains and for all the experimentally studied *LD* strains from a variety of recombination experiments. This shows very clearly the distribution of a wider range of virulence over progeny of both *MIL* and *LEE* types than is ever observed in the stock strains.

Discussion

In most of the examples which have been mentioned, it is clear that the difference between the highly virulent and the weakly virulent and non-virulent strain is not a function of a single gene. It is in accord, too, with the well-known gradualness with which virulence of a virus for a new host is built up by passage, suggesting that multiple genetic stages have intervened in the process. The development of virulence by a virus has many points of resemblance to the development of resistance to an antibiotic by a bacterium, and it is particularly interesting to find a similar pattern of results from hybridization of *E. coli* K_{12} variants, resistant and non-resistant to chloramphenicol[7]. Some of the loci concerned in these experiments could be located in relation to known biochemical markers but others could not. Cavalli and Maccaro interpreted their results as compatible with the occurrence of successive gene mutations, the genes concerned being largely at least non-allelic. Positive and negative interactions between genes were also postulated.

Recent work by Ada[8] in this laboratory makes it highly probable that influenza virus *A* does not contain deoxyribose nucleic acid as a necessary part of its structure. If only ribose nucleic acid is involved in the genetic behaviour, it may well be that the mechanisms concerned are a good deal simpler than those typical of mitosis and merosis in higher organisms. We have developed what appears to be the simplest available hypothesis to account for the results by postulating the existence of 'virulence genes' rather loosely associated with the rest of the genome. Virulence for tissue x is determined by the number of the appropriate virulence genes V^x associated with each genome. There is a considerable degree of independence in the multiplication of these units in the host cell, and the average number per genome may be modified by a variety of conditions; and in such instances as we have reported here the units may be distributed between two different types of genome. In none of the examples we have studied does this distribution appear to be a random one. If we regard serological type as the identifying mark of a virus and think of other characters in a recombinant as being transferred from the second parent, then we can speak of relative affinities of different genomes for the postulated 'floating' *V* genes. In the *MIL*–*LEE* system the V^m genes contributed by *LEE* are shared with *MIL*, but *LEE* has either a stronger affinity or loses some of its V^m's with so much difficulty that a random distribution is impossible. There is an indication, too, that in the same system it is sometimes easier to lose all V^m's than to hold a sub-standard number (cf. the undue number of non-virulent *LEE* strains).

In each of the systems we have studied there is an individuality of behaviour. In the *MEL*/*WSE* system there is no evidence of transferability of mouse-lung virulence whatever. The virulence for the chick embryo characteristic of *WSE* is, however, distributed among two of the four genomes produced (*M*+ and *WSE*), but not to *MEL* and only to a very slight extent to *WS*−. If a balance-sheet of V^e's could be constructed, one would expect an overall loss as if *MEL* and *WS*− attracted V^e's away from *M*+ and *WSE* without being able to incorporate them. Throughout the work we find a tendency in any types of manipulation in the allantoic cavity to show a loss of virulence—often slight—for other types of host cell. The neuropathogenic strains show this well. When a neuro strain is crossed with a non-neuro strain in the allantoic cavity (whether

intact embryo or de-embryonated egg) it is the rule to find a greatly reduced average mouse pathogenicity. With the *NWS/MEL* system it is easy to obtain *in vitro NM*'s, but these are mostly of very low mouse virulence. To obtain typical neuro-*MEL* strains from this combination in the chick embryo, it is much more convenient to select them from the first-cycle fluid by sub-inoculating this with anti-*WS* serum on the chorio-allantois and re-isolating strains from the embryo lesions. Similar findings were obtained in experiments with the *N–MEL/WS–* and *N–WSM/WSE* systems[9].

When a recombinant that has taken up a new virulence is passaged at limiting infective dilution, most of the *LD* fluids show the same grade of virulence; but where there is change, it is far more frequently to a lower grade, and the occasional rise is always slight.

Further work may make it necessary to postulate a more elaborate genetic mechanism for influenza virus, as Visconti and Delbrück (1953)[10] have done for the *T2* bacterial viruses. At the present time, however, it seems better to look for the simplest possible genetic mechanism that will account for the facts. In view of current thought on the nature of bacterial adaptation and recombination, it may become a valuable stimulus to the interpretation of bacterial genetics if analogies can be drawn from a simpler system such as the influenza viruses as well as from the more complex ones of classical genetic theory.

This work was supported by a grant from the National Health and Medical Research Council (Australia). [Dec. 1.

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MORPHOLOGICAL BASIS OF QUALITY IN TEA

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Scientific Department, Cinnamara, Assam

TEA breeding at this Station was begun by us in 1936 on the recommendation of a commission of inquiry led by Prof. (now Sir Frank) Engledow. Much attention has been paid to the production of tea of the quality which is characteristic of Assam and which can be obtained from no other source. For the purpose of breeding, some character indicative of quality is required.

Progress in this direction can be illustrated by quoting Hunter and Leake[1]. These authors reviewed the situation in 1933 in the following words: "The problem of tracing quality back to a character or group of characters, inherent in the plant, and sufficiently definite to form the basis of breeding, is hardly capable of solution. Nevertheless efforts in this direction have been made by Gogh (Cohen Stuart, 1930), who found differences in quality between pluckings of single trees of a magnitude which could be identified by expert tasters".

Early work by the senior author had disclosed an association between hair on the lower epidermis of the fresh leaf and the quality (as distinct from the particles known as 'tip') of the tea afterwards manufactured. This was recorded in 1936[2]. A greater number of parallel observations was required to establish a general case; these have been obtained during recent years.

We have found pubescence of the tea leaf to be genetically conditioned; and plants which are categorized in respect of hair on one occasion can be expected from experience to remain in substantially the same order. It has been observed that a crude classification of plants into five subjective hair groups by momentarily looking at the lower epidermis of the young leaves gives a significant positive correlation with quality. Even when the hair is estimated once only on a single bush in one season at the rate of 500–1,000 bushes a day, and the shoots from the same bushes are manufactured on an average of four occasions in the next season, a significant correlation is obtained ($r = 0{\cdot}260$. $P < 0{\cdot}01$). When hair is estimated with proper replicates, the correlation is found to be much closer.

This is illustrated by data in the accompanying table, which were obtained by assigning numerical indices to four subjective hair groups and by assigning numerical indices to a standard set of six degrees of comparison used by the tea taster in his reports. Seven different progenies were studied, each progeny being obtained from a mating between two clones. Six progenies were repeated as two field plots of twenty-four plants each, and one progeny as one plot of twenty-four plants. The block included two comparable plots of plants raised from a commercial source of seed which is generally recognized as possessing high quality. Samples of the plucked shoots from any one plot were spread uniformly over a shallow dish of standard size, and the amount of hair visually estimated under standard conditions of illumination. The dishes were marked by random numbers, the origin of the sample not being known to the observer. The hair was estimated on five occasions in the early part of the season. In the later part of the season shoots plucked from each one of the nineteen plots were manufactured as a separate sample. Each sample was therefore indicative of the overall quality of all the bushes in a progeny, the quality and hair of all but one of the

Progenies	Mean numerical indices for Hair	Quality
A	0·76	10·0
	0·93	28·0
B	0·88	12·0
	0·96	24·0
C	1·26	47·1
	1·07	40·0
D	1·72	42·8
	1·41	35·7
E	1·73	28·5
	1·81	34·2
F	1·79	24·0
	1·88	24·0
G (check from commercial seed)	2·17	41·4
	2·00	47·1
H	2·21	54·3
	2·44	46·1
I	2·59	66·7
	2·96	52·8
J	2·69	56·9

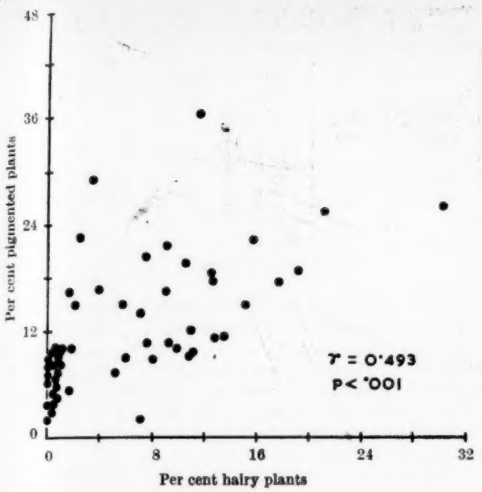

Fig. 1

progenies being determined by two plot repeats. On the first five occasions all the progenies were manufactured, after which the manufacture of the lower quality progenies was successively discontinued to enable other progenies, not relevant to the present argument, to be manufactured; the primary object of the work being to show that progenies considered desirable maintained their quality. The progenies of higher quality and the check were manufactured up to fourteen times from the end of June to early October. The taster received the samples of made tea in tins marked only by random numbers, a different assignment of numbers being used on each occasion. The nineteen pairs of variates obtained from the means of all the observations give a significant coefficient of correlation of 0·76. It is clear that hair can be taken as a reliable index of quality.

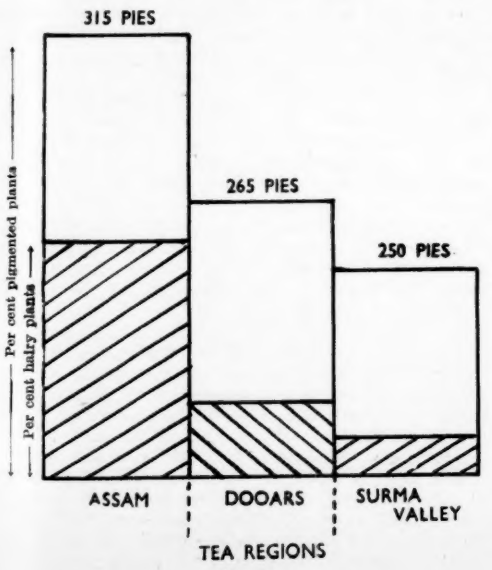

Fig. 2

Occurrence of red anthocyanin pigment in the petiole of the leaf is a genetically conditioned characteristic of a distinct type of tea plant which is probably wild in the valley of the Chindwin. This type is not in itself of value and is not cultivated in Assam. It is glabrous and lacks quality. However, the character petiole pigment must have somehow been introduced into pubescent plants which are generally cultivated and where it is now to be seen with varying but always very low frequency and with an intensity of expression much below maximum. General experience shows that, up to some low optimum, pigmentation of the leaf petiole is beneficial to quality; and above this low optimum, pigmentation is detrimental to quality.

In 1947, members of the Association supplied us with samples of seed from more than sixty commercial sources of supply in the important tea regions of north-east India. The characters of the plants raised from the seed sources of a particular region were assumed to be representative of the kind of tea plant generally cultivated in that region. The information obtained from these plants enabled us to construct Figs. 1 and 2 in which the ordinates are proportional to the separate frequencies of plants with a noticeable amount of pigment and plants with maximum hair. Fig. 1 shows a significant but not invariable association between plants with petiole pigment and plants with hair. In Fig. 2 the data are considered by regions, the numerals giving the average 1948–49 export valuation in pies for the region. There is therefore large-scale evidence in favour of the combination of some petiole pigment with hair in a population of tea plants.

Breeding experience, a description of which would be too lengthy to include in this article, supports these conclusions. If a suitable slightly pigmented plant of low quality be mated to a comparatively non-pigmented plant of good quality, then the tea made from the progeny as a whole, in bulk, is no worse than that of the good quality parent and may be better. The pigment disappears in the offspring to all but the experienced eye at the appropriate season. Vigour can be improved by a mating of this nature; and if the vigour is improved then it may be associated with a uniformity among the offspring greater than is usual among cultivated tea plants. The object of tea breeding is to perpetuate favourable parents vegetatively, so as to obtain a permanent source of F_1 seed.

It is necessary to emphasize that successful use of the breeding operations to which we refer here requires considerable experience. The introduction of petiole pigment in sufficient quantity to be noticed by the untrained eye is likely to reduce quality. Typically, petiole pigment is associated with a dominant glabrous condition. It is therefore necessary to introduce the pigment into an F_1 from the comparatively rare combination of some pigment with sufficient hair. Slightly pigmented plants when bred among themselves may produce undesirable segregates. The morphological criteria require more detailed description than is possible in this article, the object of which is to indicate the progress which has been possible in recent years.

We wish to thank the Director, Tocklai Experimental Station, and the Indian Tea Association for permission to publish these results. [Dec. 4.

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LETTERS TO THE EDITORS

The Editors do not hold themselves responsible for opinions expressed by their correspondents. No notice is taken of anonymous communications

Thorium Determination in Deep-Sea Sediments

A method for direct measurement of ionium (thorium-230) has been described in a previous communication[1]. Ionium was measured in samples of red clay from the Central Pacific Ocean raised by the Swedish Deep-Sea Expedition (1947–48).

The chemical procedure leads to the isolation, together with ionium, of other thorium isotopes: thorium-227 (Rd-Ac), thorium-228 (Rd-Th) and thorium-232, all α-emitters.

The photographic method permits individual measurement of the activity of these various isotopes: ionium and thorium-232 give only single tracks while a fraction of the disintegrations of Rd-Th and Rd-Ac leads to the production of five-branched stars.

This fraction is a known function of the time of exposure in the emulsion[2–5].

If thorium and Rd-Th are in equilibrium, the number of five-branched stars from Rd-Th is a measure of the thorium-232 concentration.

We can measure with the double emulsion technique[6] as little as 10^{-9} gm. of thorium, provided it is concentrated in a drop of a few microlitres. Care must be taken to prevent the loss of thoron. Experimental details will be published elsewhere.

Rd-Ac also gives five-branched stars and can interfere in the measurements of Rd-Th. In deep-sea sediments, Rd-Ac can originate from two sources: (1) Rd-Ac in equilibrium with uranium-235. If the uranium concentration is known, it is easy to calculate the correction, which in our samples was always less than 5 per cent (values given by Hecht[3]). (2) Rd-Ac produced by protactinium precipitated in excess from the ocean. Although we do not know the concentration of protactinium in sediments, we have certain criteria to control the source of five-branched stars: (*a*) rate of growth of the star population with increasing time of exposure in the photographic emulsion; (*b*) decrease of Rd-Ac (half-life, 19 days), while the Rd-Th remains practically constant (half-life, 1·9 years); (*c*) presence of the characteristic long α-track of thorium C′; (*d*) rate of decrease of star activity with depth in the sediment (assuming a rate of sedimentation of 1 mm./1,000 years, any protactinium isolated from uranium-235 must be completely disintegrated below 15 cm. from the top of the sediment).

Thorium has been measured in samples of red clay from the Pacific Ocean. The results are grouped in the accompanying table (col. 4). The concentration of thorium has been calculated from the five-branched star production, assuming thorium to be in equilibrium with Rd-Th and ascribing all the five-branched stars to Rd-Th. Absence of appreciable amount of Rd-Ac stars is proved by length measurement of α-tracks of thorium C′ on samples 11 and 12 and by the independence of the number of stars of the depth in the sediment.

The number of samples is not yet sufficient to allow any definite conclusion. Still, we can see that the thorium content does not seem to change appreciably from one sample to another. The figures are grouped around the value 5×10^{-6} gm. Th/gm. dried red clay. This value is much higher than the figures found by Koczy[7] in red clay from the Atlantic Ocean. Dr. Koczy has pointed out in a private communication that the difference could be ascribed either to the higher sedimentation-rate prevailing in the Atlantic Ocean, or to incomplete extraction of thorium due to his use of hydrochloric acid extraction instead of dissolution of the samples.

Thorium in Red Clay from Central Pacific Ocean. Cores of the Swedish Deep-Sea Expedition (1947–48)

Sample	Core	Depth in sediment	Th 10^{-6} gm./gm. dry sediment
Blank test (UX_1 + reagents + photographic emulsion)			<0·03
9	87 *B*	33 cm.	4·1 ± 0·4*
3	87 *B*	47 cm.	3·1 ± 0·6
4	83	4 cm.	6·0 ± 0·6
11	86 *B*	12 cm.	5·8 ± 0·4
12	86 *B*	17 cm.	5·4 ± 0·4
13	86 *B*	49 cm.	8·5 ± 3

* Statistical errors only.

The uranium-content has been measured by Hecht[3] in other samples from the same cores. He obtains values grouping mostly between 1·5 and 2·5 × 10^{-6} gm. U/gm. This seems to indicate that in these red clays the thorium – uranium ratio is a little lower, but of the same order of magnitude as the average value in continental rocks.

Chronology of deep-sea sediments by ionium-thorium ratio. Attempts have been made to use the vertical distribution of radium (assumed to be in equilibrium with ionium) for dating back to 350,000 years deep-sea sediments[8].

This method, which is based on the fact that ionium produced by uranium dissolved in sea-water is precipitated together with the sediments[1,9,10], involves some assumptions difficult to check on the rate of precipitation of ionium.

A method based on the ratio ionium – thorium (ratio of two isotopes, one of which is practically stable while the other decays with a half-life of 80,000 years) should be free from this criticism. Such a method would be valid only if: (1) the ionium – thorium ratio in the ocean has remained constant in the time-interval considered (maximum ~ 350,000 years); (2) thorium is precipitated from the sea-water in the same proportion as ionium.

This last hypothesis requires that both ionium and thorium should be dissolved in the same chemical form in sea-water and that all the thorium contained in the sediments should have been chemically precipitated from the sea and not carried in mineral residues.

This hypothesis can be tested by comparing the ionium – thorium ratio in sea-water and in the surface layers of deep-sea sediments or, following a suggestion of H. Pettersson during discussion, by checking if thorium and ionium in the sediments have the same chemical behaviour.

Assuming this condition to be fulfilled, the ionium – thorium ratio in any layer of a sediment column will be found independent of changes, both of the rate of total sedimentation and of the rate of precipitation of thorium and ionium, and should depend only on the time elapsed since the deposition of the layer.

We wish to thank the Oceanographical Institute of Göteborg and the Geological Society of America for financial support. We are indebted to Prof. H. Pettersson and Dr. Koczy for helpful suggestions and to the Misses N. Isaac and G. Poulaert for their

assistance in the chemical separations, and to Prof. G. P. S. Occhialini for useful criticism.

E. Picciotto
S. Wilgain

Centre de Physique Nucléaire,
Université Libre de Bruxelles. Dec. 23.

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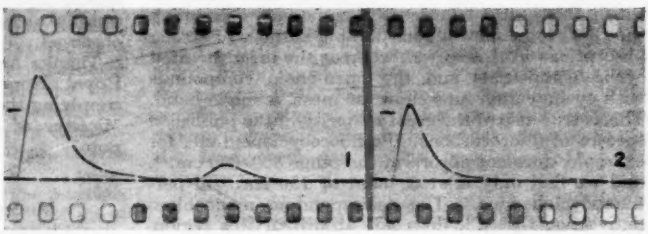
Electron Energy Distribution in the Striated Hydrogen Discharge

The distribution of energy among the plasma electrons is a factor of primary importance in determining the processes occurring in a discharge. Two matters of special interest in our work are (*a*) the processes determining the equilibrium of negative ions in electronegative plasmas, and (*b*) the mechanism of production of atomic hydrogen in discharges in dry and wet hydrogen. In the first, the case of oxygen is well known to be somewhat anomalous in that the negative ion concentration is very much less than it is in the halogen plasmas, although the electron affinity is not vastly different. In case *b*, the much greater efficiency of radio-frequency discharges for dissociating H_2 and the fact that increased dissociation resulting from an introduction of water vapour does not seem to be entirely attributable to wall poisoning, suggests that the difference between the energy distribution for electrons in a striated positive column and that in the radio-frequency discharge may be concerned in the changed efficiency. The purpose of this communication is to direct attention to some preliminary results for energy distributions in the positive column of a d.c. discharge in hydrogen.

The method employed makes use of the result of Druyvesteyn[1] that for an isotropic distribution the energy distribution function is given by $f(E) = V^{1/2}.\frac{d^2i}{dV^2}$ where i is the current to a Langmuir probe at a potential V with respect to the space. The quantity $\frac{d^2i}{dV^2}$ may be determined in various ways, namely, by graphical double differentiation; by making $V \propto t$ (time) and evaluating $\frac{d^2i}{dt^2}$ using resistance capacity circuits[2]; by the use of a bridge circuit[3]; and by noting the change in the mean value of i when V has superimposed upon it a small a.c. component[4].

We have used a development of the last method. When a modulated carrier frequency of voltage is superimposed upon the probe potential, then for small carrier amplitudes the component of modulation frequency in the probe current is proportional to $\frac{d^2i}{dV^2}$. If, by means of a linear potential divider, V is now made to vary slowly and a square root law potential divider is varied at the same time by direct coupling, then with the aid of suitable tuned amplifier circuits the product $V^{1/2}.\frac{d^2i}{dV^2}$ may be continuously presented on an oscillograph. By means of beam switching, the apparatus provides a photographic record of both the energy distribution function and a Langmuir probe characteristic. (The latter is not shown in the accompanying photographs.) At the end of a recording a modulation frequency voltage of known amplitude is applied to the amplifying equipment to enable a scale to be fitted to the energy distribution curve. The energy axis is calibrated by suppressing the oscillograph spot at convenient voltage intervals.

The accompanying figures give some preliminary results obtained in a hot cathode discharge in hydrogen at 0·055 mm. mercury pressure and a tube current of 200 mA. In Fig. 1, the probe is located in the brightest part of the striation. Attention is directed to the presence of a group of electrons having energies considerably greater than the mean. In Fig. 2 the probe is in the middle of the dark space between striations. (In the figures the short horizontal line represents a concentration of 10^9 electrons/c.c./volt energy range, and the oscillograph spot has been suppressed at 2-volt intervals.)



It is appreciated that the anisotropy of the velocity distribution, particularly in the regions of high field, reduces the precision of the results. An energy spectrometer employing a collimated sample beam and analysis by retardation is under construction. It is hoped to publish further details, both of the experimental methods and of results and conclusions, at a later date.

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Infra-red Spectra of Fluorinated Hydrocarbons

We have recently examined for analytical purposes the infra-red spectra of some fully fluorinated hydrocarbons. Complex interactions occur in compounds of this type, and it is not to be expected that the absorption frequencies of any particular structural group will be constant: but nevertheless some regularities have been observed which may be useful.

	Perfluoro compound	800–650 cm.$^{-1}$	860–840 cm.$^{-1}$
1	Decalin	—	860, 845
2	2 : 7 Dimethyl decalin	742*	853
3	2 : 3 Dimethyl decalin	738*	850
4	1 : 6 Dimethyl decalin	744*	843
5	2 : 6 Dimethyl decalin	738*	850
6	1 : 2 Dimethyl cyclohexane	733*	859
7	1 : 6 Dicyclohexyl hexane	662	849
8	1 : 5 Dicyclohexyl pentane	669	848
9	1 : 4 Dicyclohexyl butane	676	848
10	1 : 2 Dicyclo hexyl éthane	709	848
11	Dicyclohexyl methane	720	845
12	Dicyclohexyl	738	852

* Denotes compound with CF—CF_3 group

The spectra of simple fluorine-containing compounds have been studied by several workers, and more complex molecules have been examined by Thompson and Temple[1] and by many others[2–7]. Some spectra are also included in the American Petroleum Institute (A.P.I.) series. However, in none of the latter cases are any vibrational assignments available.

The compounds examined are listed in the table. They were used as liquid capillary films or as solid mulls in paraffin, and the spectra were obtained with a Perkin–Elmer 21*B* double-beam automatic recording spectrophotometer with a rock-salt prism.

The most striking feature of the spectra examined is the contrast between the number and intensities of absorption bands in the range 800–650 cm.$^{-1}$ in materials containing the CF_3 group and those in which this group is absent. Compounds containing the CF_3 group show a considerable number of strong absorptions in this region, whereas the unsubstituted cyclic compounds and the open-chain compounds with cyclic end-groups show, at most, a single band. This is true also of the great majority of the published spectra of fluorocarbons. Perfluorocyclopentane, for example, does not absorb in the range 800–650 cm.$^{-1}$, and we find only a weak band at 730 cm.$^{-1}$ in perfluorocyclohexane. The corresponding monochloro derivative, $C_6F_{11}Cl$, does not absorb in this region. Neither perfluorodecalin nor any of the compounds in the series perfluorodicyclohexyl methane to perfluorodicyclohexyl hexane shows more than a single band in the range 800–650 cm.$^{-1}$.

Closer examination of this region reveals that a band occurs consistently in the range 745–730 cm.$^{-1}$ in the spectra of those compounds which contain the CF—CF_3 or CF_2—CF_3 group. This suggests that some vibration of the CF_3 group, possibly the deformation mode, may be sufficiently stabilized in frequency when it is adjacent to a CF or CF_2 group to give a characteristic absorption. With this possibility in mind, we have examined the spectra of as many fluorinated compounds as we have been able to trace in the literature. Spectra of partially fluorinated aromatic compounds have been ignored, as aromatic ring vibrations can be expected to absorb in the same region; but apart from these we have found that a band in the 745–730 cm.$^{-1}$ region appears in the spectra of 35 out of 48 compounds containing the CF—CF_3 or CF_2—CF_3 group, and that apart from perfluoroethane[2], which may be expected to be abnormal, all the exceptions contain functional groups in the immediate vicinity of the CF—CF_3 group. Thus, the great majority contain the structure *R*—CO, *R*—C= on *R*—CFCl, in which interactions are only to be expected. In contrast to this, only six of fifty-six fluorinated compounds which did not contain the group showed absorption in the stated region. It appears, therefore, that the CF—CF_3 or CF_2—CF_3 group will give rise to absorption in the 745–730 cm.$^{-1}$ region provided it is sufficiently far removed from the influence of functional groups. This is particularly well illustrated by the spectra of the compounds $C_3F_7.COOCH_2CF_3$ [3] and $C_3H_7.COOCH_2CF_3$ [4]; $C_3F_7.COOC_2H_5$ [3] and $C_3H_7.COOC_2H_5$ [3]; and C_2F_7—S—S—C_2F_7 [4] and CF_3—S—S—CF_3 [5]. The first compound of each of these pairs absorbs strongly at 740 cm.$^{-1}$, whereas the second does not.

Another interesting feature of our spectra is the single absorption band in the range 800–650 cm.$^{-1}$ shown by the series of compounds perfluorodicyclohexyl hexane to perfluorodicyclohexyl. The first member absorbs at 662 cm.$^{-1}$ and the band moves progressively towards higher frequencies with decrease in the number of carbon atoms separating the two rings. Perfluorodecalin shows a similar band at 755 cm.$^{-1}$ and it may be associated with a C—F deformation.

In all the compounds we have examined, and in all the spectra of fully fluorinated cyclic compounds in the A.P.I. series, a band appears in the range 860–840 cm.$^{-1}$. This may be associated with a ring CF_2 vibration since it is usually absent from the spectra of open-chain materials; but it could also arise from the C—C vibrations of the ring.

The perfluorodecalin and the dicyclohexyl compounds also show complex patterns of intense bands in the range 1,350–1,200 cm.$^{-1}$ arising from C—F stretching-modes; but these vary considerably with small structural changes and no regularities can be observed.

Thanks are due to Dr. N. L. J. Megson, of the Royal Aircraft Establishment, Farnborough, for supplying the samples and also to the Chief Scientist, Ministry of Supply, for permission to publish this note.

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Use of Adsorption Columns in the Analysis of Soap and Detergent-stabilized Emulsions

Methods at present available for the determination of the total materials in aqueous emulsions involve cracking the emulsion, separating the non-aqueous phase by solvent extraction or filtration, and weighing the products prior to analytical investigation. The need for a rapid means of isolating the components of such systems has led to the development of a technique employing adsorbents containing an ion-exchange resin, whereby the separation of an oil-in-water emulsion (for example, wool-scouring liquors) can be achieved. This has been suggested previously[1] as being applicable to large-scale cracking and recovery of emulsified grease from industrial effluents.

In the present work, using columns of 'ZeoKarb 225' ('Permutit') in bead form, mixed with powdered animal charcoal, percolation of soap solutions and emulsions gave clear liquors from which organic matter had been removed. The presence of charcoal diminishes the rate of percolation that occurs with resin alone and increases the extent of adsorption: it is not yet clear whether the charcoal functions purely mechanically or as an additional adsorptive material. Preparation of the columns involves regeneration of the resin and Soxhlet extraction with the solvents to be used for elution. Percolation of the emulsion and subsequent elution with a series of solvents resulted in the isolation of the separate components. With pure soaps, over the concentration-range 0·05–0·4 per cent, elution with ethanol gave a 98–100 per cent recovery of the corresponding fatty acids; with purified, substantially acid-free lanolin, stabilized by pure soaps, ethanol elution gave a 99 per cent yield of fatty acid (calculated on the soap used), and subsequent elution with trichlorethylene gave a 99 per cent yield of lanolin. These two fractions were identified with the pure materials by means of their infra-red absorption spectra, which are characteristic. The fatty acid was also determined by alkali titration.

Under these conditions, therefore, it is possible to obtain an almost theoretical yield of the separate components quite readily. In the case of sodium cetyl sulphate, the pure material was retained on the column, but proved most difficult to remove. Eventually, it was found that elution with ethylene glycol and subsequent titration with aqueous sodium hydroxide indicated a 100 per cent yield of cetyl hydrogen sulphate (identified as cetyl alcohol after hydrolysis with hydrochloric acid). Emulsions stabilized with sodium cetyl sulphate were also estimated, the lanolin being removed from the column by trichlorethylene, and the cetyl hydrogen sulphate afterwards removed and determined as above.

This method has been extended to the analysis of emulsions of a mineral oil (Shell 'Clavus 27') and of a vegetable oil (olive oil), reproducible results being obtained. A more detailed account of the work will be published elsewhere.

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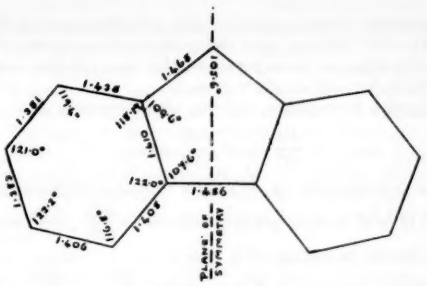
Molecular Structure of Fluorene

There has been considerable discussion during the past thirty years or so about the shape and in particular about the planarity of the fluorene molecule. If the molecule is not flat, then there is the possibility of obtaining optical isomers with unsymmetrically substituted fluorene derivatives, and some claims have been put forward that such isomers have been resolved. A qualitative estimation of the main X-ray crystal reflexions from fluorene together with optical and magnetic data led one of us some years ago[1] to the conclusion that the fluorene molecule was non-planar. The consequences in regard to optical isomerism were discussed by Cook and Iball[2], who gave a brief review of the literature on the subject.



Fluorene ($C_{13}H_{10}$)

We have now completed a detailed quantitative crystal analysis of this compound, including two-dimensional Fourier syntheses down each of the three axes of the orthorhombic unit cell. Full details of the analysis will be published elsewhere. Here we wish to give the results in regard to the size and shape of the molecule. The accompanying figure gives the bond-lengths (A.) and the bond-angles. The mean bond-length in the benzene ring is 1·403 A. with a standard deviation of 0·007 A. The space group is *Pnam*, and therefore, since there are only four molecules per unit cell, the molecule possesses a plane of symmetry which coincides with the (001) plane of the crystal. The carbon atoms all lie on a plane which can be represented in the unit cell by the equation $y = 1{\cdot}4375x + 11{\cdot}0947$ (unit cell dimensions are, $a = 8{\cdot}49 \pm 0{\cdot}01$; $b = 5{\cdot}72 \pm 0{\cdot}01$; $c = 18{\cdot}97 \pm 0{\cdot}10$ A.). The maximum deviation of the atoms from this plane is 0·030 A.; root mean square deviation is 0·017 A. It is clear, therefore, that the molecule is planar, and unless the molecule has a different shape in solution from that which it has in the solid there can be no possibility of optical isomerism.

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Bashforth–Adams Method for the Numerical Solution of Differential Equations

Several current text-books on numerical mathematics give descriptions of what is called the 'Bashforth–Adams' process for the solution of differential equations. The method is usually dismissed with a statement to the effect that, since it includes no adequate checking procedure, it is of little use.

Now, although this remark is true of the process envisaged by the authors of the texts, it is not true of the technique developed by Bashforth and Adams, which we can only suppose has been successively retranscribed from some incorrect secondary source by later writers.

To set the matter right, it was thought worth while to publish the following brief note. Page

references are to pages of the original text of Bashforth and Adams[1], and the notation is as given there, except that we have replaced the (Δu_0) of the original authors by the modern (∇u_0).

In the first place, taking the equation as:

$$\frac{d^2y}{dt^2} = f\left(\frac{dy}{dt}, y, t\right) \quad (1)$$

it is pointed out (p. 16) that repeated differentiation of (1) will enable general values of $\frac{d^3y}{dt^3}$, $\frac{d^4y}{dt^4}$, etc., to be found in terms of y and t.

Next, assuming that $y = y_0$, $\frac{dy}{dt} = \left(\frac{dy}{dt}\right)_0$ when $t = t_0$, expansions for y_1 and $\left(\frac{dy}{dt}\right)_1$ at the end of an interval (δt_0) are given as Taylor series:

$$y_1 = y_0 + \left(\frac{dy}{dt}\right)_0 (\delta t_0) + \frac{1}{2!}\left(\frac{d^2y}{dt^2}\right)_0 (\delta t_0)^2 + \ldots$$

$$\left(\frac{dy}{dt}\right)_1 = \left(\frac{dy}{dt}\right)_0 + \left(\frac{d^2y}{dt^2}\right)_0 (\delta t_0) + \frac{1}{2!}\left(\frac{d^3y}{dt^3}\right)_0 (\delta t_0)^2 + \ldots$$

These are to be used to find initial values of y_n, $\left(\frac{dy}{dt}\right)_n$ $(n = 1, 2, \text{etc.})$, to start subsequent interpolatory processes, and some observations on the use and convergence of such Taylor series follow.

From this point the authors address themselves to the solution of the type of equation of principal interest in their own work:

$$\frac{dy}{dt} = f(y,t) \quad (= f, \text{ say}). \quad (2)$$

The backward difference interpolation formula:

$$f_n = f_0 + \frac{n}{1!}\nabla f_0 + \frac{n(n+1)}{2!}\nabla^2 f_0 + \ldots$$

is integrated (p. 18) to give:

$$y_0 - y_{-1} = \int_0^{-1} f_n dn,$$

or

$$y_0 = y_{-1} + (\delta t)\left[f_0 - \frac{1}{2}\nabla f_0 - \frac{1}{12}\nabla^2 f_0 - \frac{1}{24}\nabla^3 f_0 - \frac{19}{720}\nabla^4 f_0 - \frac{3}{160}\nabla^5 f_0 - \ldots\right] \quad (3)$$

and

$$y_1 - y_0 = \int_0^1 f_n dn,$$

or

$$y_1 = y_0 + (\delta t)\left[f_0 + \frac{1}{2}\nabla f_0 + \frac{5}{12}\nabla^2 f_0 + \frac{3}{8}\nabla^3 f_0 + \frac{251}{720}\nabla^4 f_0 + \frac{95}{288}\nabla^5 f_0 + \ldots\right] \quad (4)$$

It is the second of these formulæ which is usually given as the basis of the Bashforth–Adams method, whereas, in fact (p. 19), the authors suggest that (4) be used to predict a value for y_1 and that this value is to be checked and, if necessary, corrected by means of (3), which they rightly point out is of much greater accuracy than (4) for the same number of terms.

The analysis concludes with some formulæ for the cyclic refinement of a predicted value when the difference between this and the more accurate version obtained by means of (3) is small enough for squares to be neglected (pp. 19–20).

Tables are also provided (pp. 58–62) to facilitate the calculation of the quantities $\frac{19}{720}\nabla^4$, $\frac{3}{160}\nabla^5$, etc., occurring in (3), and give additional proof that the correction formula was intended for serious use.

It will be clear to the reader that the full method, as described above, is an eminently practical one, and that it differs only very slightly (in the detailed formulæ) from the prediction–correction process usually known as Milne's method, which is much favoured at the present time.

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Osmotic Pressure of Bull Semen Diluents

Bull semen is usually diluted with egg yolk phosphate[1] or egg yolk citrate buffer[2] before being used for artificial insemination. The former consists of equal volumes of freshly separated egg yolk and phosphate buffer, *p*H 7·4 (2 gm. $Na_2HPO_4.12H_2O$, 0·2 gm. KH_2PO_4 and water to 100 ml.); the latter consists of equal volumes of egg yolk and sodium citrate (2·9–3·9 gm. $Na_3C_6H_5O_7.2H_2O$ and water to 100 ml.; *p*H adjusted to 6·8 by addition of citric acid, 2·8–10 per cent). Various combinations of bacteriostatic and/or bactericidal substances are often added to these semen diluents. The freezing point depressions (Δ) of these diluents, of certain others, and of bull seminal plasma were measured by Ramsay's micro-method[3], and the results are given in Table 1. The value given for bull seminal plasma is the mean of forty determinations, using ten bulls of different breeds (Ayrshire, Dexter, Red Poll, Shorthorn and Friesian) over a period of one month. The standard error of $\bar{\Delta}$ $(-0·53)$ is 0·005. Dr. R. Aschaffenburg, of the National Institute for Research in Dairying, Shinfield, has obtained very similar values to those quoted above, using the Hill–Baldes vapour-pressure technique (personal communication).

Table 1. Freezing Point Depressions (deg. C.)

Bull seminal plasma	− 0·53
Phosphate buffer + egg yolk (equal vol.)	− 0·45
Citrate buffer, 3·92 per cent* + egg yolk (equal vol.)	− 0·63
Citrate buffer, 3·4 per cent + egg yolk (equal vol.), containing 0·15 per cent sulphanilamide and 250 I.U. streptomycin calcium chloride/ml.	− 0·64
Sperm Ringer (Mann, 1946)	− 0·53
SGC-2 (Milovanov, 1938)	− 0·59
0·9 per cent sodium chloride	− 0·54

* w/v here and elsewhere.

The most recent other experiments on this subject are those of Salisbury *et al.*[3]. They found that $\bar{\Delta}$ of bull semen, as distinct from seminal plasma, was − 0·587. We found it impossible to measure the freezing point depression of bull semen accurately, using Ramsay's method, because of the opacity of the semen. Apart from this, the freezing point depression of seminal plasma is more meaningful than the freezing point depression of semen, which, in the case of the experiments of Salisbury *et al.*, consisted of seminal plasma containing an unspecified number of dead spermatozoa, the effect of which on such measurements is unknown.

Not much evidence is available on the tolerance of bull spermatozoa to media with different osmotic pressures; but it would seem desirable to use a diluent with about the same osmotic pressure as seminal plasma. In the case of egg yolk citrate buffer containing 0·15 per cent sulphanilamide, this can be achieved by using equal volumes of egg yolk and a 2·875 per cent solution of sodium citrate ($2H_2O$), made up in water containing 0·3 per cent sulphanilamide, brought to *p*H 6·8 with 5·6 per cent citric acid, also made up in water containing 0·3 per cent sulphanilamide. In the case of egg yolk phosphate buffer containing 0·15 per cent sulphanilamide, a mixture containing equal volumes of egg yolk and phosphate buffer (2 gm. $Na_2HPO_4.12H_2O$, 0·2 gm. KH_2PO_4 + 75 ml. water containing 0·3 per cent sulphanilamide) is isotonic with bull seminal plasma. The concentrations in which penicillin and streptomycin are normally added are such as to have only a small effect on the osmotic pressure of the diluent. The freezing point depression of egg yolk itself is − 0·58 to − 0·60 [6].

This work is supported by the Medical Research Council; further details will be published in due course.

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Semen Diluents in the Artificial Insemination of Cattle

A NUMBER of studies have been made of the effects of different diluents, with and without the addition of bactericidal or bacteriostatic substances, on the fertilizing capacity of bull semen. Experiments in the United States, where most of the investigations have been made, have been reviewed by Easterbrooks[1], while Rottensten and Oestergaard[2] have described a series of experiments in Denmark; but no systematic examination of this problem has been made in the United Kingdom, and the American experiments have been on a comparatively small scale, which obviated the possibility of a comprehensive investigation. A large experiment in Britain, involving four Milk Marketing Board artificial insemination centres and their sub-centres, was therefore started in February 1951. The experiment was designed to find out which of the two diluents commonly used in artificial insemination, egg-yolk citrate buffer (equal volumes of 3·2 per cent sodium citrate, *p*H adjusted to 6·8 with citric acid, and egg-yolk) and egg-yolk phosphate buffer (equal volumes of phosphate buffer, *p*H 7·4 (2 per cent $Na_2HPO_4.12H_2O$ and 0·2 per cent KH_2PO_4 and egg-yolk), was the better in the sense of being associated with the higher conception-rate, the buffers being used with and without all possible combinations of sulphanilamide (1·5 mgm./ml.), penicillin (500 units/ml.) and streptomycin (500 μgm./ml.).

The experiment involved the insemination of 68,713 cows with semen from 134 bulls; the split-sample technique was used throughout. A considerable fraction of the computations involved in the analysis of the results was done on EDSAC I, and we are much indebted to Dr. M. V. Wilkes, director of the Mathematical Laboratory, Cambridge, for allowing the electronic calculator to be used for this purpose.

The results show that: (1) egg-yolk phosphate buffer + penicillin improved the conception-rate, as compared with egg-yolk citrate buffer alone, by 9·3 per cent; (2) egg-yolk citrate buffer + sulphanilamide, penicillin and streptomycin improved the conception-rate, as compared with egg-yolk citrate buffer alone, by 6·8 per cent; and (3) egg-yolk phosphate buffer alone was 5·5 per cent better than egg-yolk citrate buffer alone.

The difference between the improvements cited in (1) and (2) is insufficient to justify the adoption of egg-yolk phosphate buffer + penicillin at artificial insemination centres, particularly as egg-yolk citrate buffer has certain advantages, from the point of view of the visibility of the spermatozoa in it, over egg-yolk phosphate buffer. The increase in conception-rate using egg-yolk citrate buffer + sulphanilamide, penicillin and streptomycin is, however, of considerable economic importance.

The details of this work will be published elsewhere.

We are indebted to Sir Ronald A. Fisher for his guidance in the statistical analyses; and also to the members of the Milk Marketing Board's veterinary and technical staffs for their invaluable co-operation in these experiments.

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Artificial Production of Incomplete Influenza Virus

DIFFERENT strains of influenza virus yield different proportions of incomplete particles on heavy infection of the allantois[1]; and members of the influenza group can be arranged in a gradient based on this property[2]. The phenomenon itself remains unexplained, as is, indeed, the mechanism of incomplete virus production. In an approach to this problem we searched for other characteristics which would vary in gradient fashion, and hoped to establish a correlation between some better-known viral functions and the change in infectivity.

We have examined the rate of adsorption and elution in the allantois, the 'minimum receptor requirements', the extent to which the strains can inactivate the receptor substance, and the speed with which they are taken up by cells. All these properties showed uneven distribution among the strains, as

will be published in detail elsewhere. However, to date only the rate of viropexis appeared to give the same gradient as that of incomplete virus production, the strain taken up fastest (*LEE*) producing the smallest proportion of incomplete particles. On the strength of this observation the following working hypothesis was formed.

In the period between adsorption to infectible cells and viropexis the particles 'browse' over the surface of the cells[3], that is, during their two-dimensional thermal movement the viral enzyme groupings will come into contact with specific substrate groups, act on them, and thus reduce the average concentration of substrate over the whole cellular surface. Obviously, the decrease in substrate concentration will be proportionate to the relative number of enzyme units, and to the average time the virus spends outside the cell. It is assumed that a certain amount of intact receptor substance is required for complete virus production, and that below a critical substrate density the cell will produce non-infective particles. The fact that incomplete virus is produced (*a*) only in the first cycle, (*b*) only after heavy infective inocula, and (*c*) to different extents in different strains, is explained by (*a*) the first cycle being considerably longer than any subsequent cycles[4], due mainly to slower viropexis[5]; (*b*) that effective reduction of overall substrate density can be achieved only by large numbers of virus particles acting for a long time; and (*c*) that different strains spend different periods on the outer surface of the membrane prior to being taken up. It follows from the foregoing that a treatment which renders the substrate non-attackable or which reduces the lag between adsorption and uptake should prevent the production of incomplete virus; similarly, artificial destruction of the substrate—provided it does not also prevent infection—should result in the production of incomplete particles even in those strains where this would not normally occur, and even after dilute inocula where it is not known to occur with any strain.

The crucial experiment was built around the 'receptor modifying' effect of the metaperiodate-ion[6]. It is known that influenza virus enzymes cannot act on cellular receptors which have been oxidized by appropriate amounts of IO_4^-; however, such cells are still infectible by the virus. Thus, eggs were given allantoic inocula of 1·0 ml. 0·01 *M* potassium periodate, and an hour later 0·25 ml. 0·1 *M* glycerol to neutralize excess periodate. Following this, 10^4 or 10^5 ID_{50} of fresh *PR*8 (*A*) or *LEE* (*B*) virus were inoculated. The fluids, harvested at the height of infectivity (that is, sixteen hours after the concentrated and forty-two hours after the dilute seed), were titrated for infectivity and hæmagglutinin content. The results are shown in the accompanying table.

Production of Incomplete Virus in IO_4^- Treated Eggs

Treatment	Inoculum Strain	Inoculum Dose	Replicates	Yield *ID*/ml.	Yield *HA*/ml.	Yield *ID*/*HA* ± st. error
Nil	*PR*8	10^5	15	7·61	3·35	4·26±0·18*
		10^4	18	9·32	3·31	6·01±0·16
	LEE	10^5	25	9·24	3·12	6·11±0·09
		10^4	17	9·03	2·85	6·17±0·09
KIO_4	*PR*8	10^5	18	6·48	2·54	3·95±0·19*
		10^4	15	7·73	2·98	4·75±0·12*
	LEE	10^5	16	7·83	3·05	4·78±0·13*
		10^4	17	7·61	3·29	4·31±0·14*

Geometric mean infectivity (*ID*) and hæmagglutinin (*HA*) titres are expressed in $\log_{10}$ units.
Significant production of incomplete virus is marked with an asterisk.

The normal ratio of infectivity to hæmagglutinin (*ID*/*HA* ratio) is $10^{6\cdot26}$. In the absence of pretreatment with IO_4^- both strains attain this ratio after dilute inocula, and *LEE* even after the concentrated one; thus only large doses of *PR*8 lead to the production of 'incomplete' virus particles, with a resultant drop in the *ID*/*HA* ratio. After IO_4^- treatment, on the other hand, all combinations of strains and inocula show ratios significantly lower than the normal, more than 90 per cent of the particles yielded being incomplete. Control experiments have satisfied us that the target of IO_4^- action was the host cell and not the infecting virus.

These results amount to the realization of the second set of predictions, and thus to a positive proof of our hypothesis. The rest of the predictions, which should constitute the indirect proof, are either not amenable to experimental testing—there are at present no means known to render the intact substrate non-attackable—or are well-established empirical facts, namely, the absence of incomplete virus production in later cycles.

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Influence of Nitrate Ion upon the Synergistic Effects of Glucose and *k*-Strophanthoside

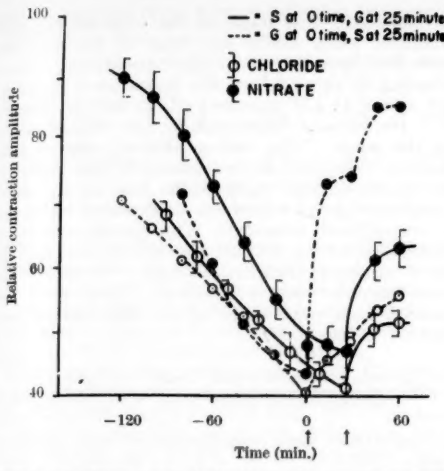
In the present report, we offer evidence to show that glucose is one of the factors limiting the positive inotropic response of the driven ventricle to *k*-strophanthoside (Strophosid-Sandoz), and that the magnitude of the reaction to glucose is greater when nitrate rather than chloride is the chief anionic constituent of the nutrient medium.

Electrically driven strips of rats' ventricles were employed as the test objects in the present study. Since the methods of preparing the muscle sections and other details of experimental technique have already been described in previous reports from this laboratory[1–3], details of methodology will be omitted from the present communication. All experiments were made in the presence of continuously flowing media that were replenished at the rate of 500 ml./hr. and gassed by a vigorous flow of oxygen through the muscle chamber. The *p*H of the solutions at 37° C. was 8·3.

The strips were first standardized on 'reference' solution (see table) and then subjected to a low (3·2 m*M*) calcium glucose-free solution in order to accelerate the 'tiring' process.

Composition of Standard Reference Solutions (Millimoles per Litre)

	Na	K	Ca	Glucose
NO_3 or Cl	154	5·63	5·59	
HCO_3	7·15			5·56



Effect of glucose and *k*-strophanthoside on hypodynamic ventricles. Activity values shown above are expressed relative to the amplitude developed during pre-experimental equilibration on standard reference solution. Negative time identifies the post-standardization fatigue period; *S*, the addition of *k*-strophanthoside (final concentration $5{\cdot}73 \times 10^{-4}$ m*M*); and *G*, the administration of glucose (final concentration 5·56 m*M*). The plotted points in each experimental category are mean values obtained on five ventricle strips and the vertical lines are their respective standard errors

When the activity of driven ventricle strips that were maintained on the latter solutions had declined to about 50 per cent of the equilibration value, the addition of glucose produced an increase in the contractile response which could be potentiated by the subsequent addition of *k*-strophanthoside. There was no enhancement of the contraction amplitude if *k*-strophanthoside were added in the absence of glucose. The accompanying figure illustrates that the addition of the drug to the medium in a quantity sufficient to yield a $5{\cdot}73 \times 10^{-7}$ molar concentration of *k*-strophanthoside (calculated on the assumption that the molecular weight is 872 [4]) has no effect until subsequent treatment with glucose.

The influence of inorganic anions upon the response of the substrate-depleted muscle to glucose can be assessed by comparing the two dashed curves in the figure. Within the time restrictions of the test, the response of the fatigued muscles to the addition of glucose was greater in nitrate- than in chloride-Ringer's. Although the subsequent administration of *k*-strophanthoside produced an enhancement of contraction amplitude, the increase was of a lesser magnitude in the case of chloride than of the nitrate series.

Our findings concerning the potentiating effect of nitrates upon the inotropic response to glucose are in general accord with the observations of Sandow[5], who found that the twitch-tension of the frog's gastrocnemius was augmented in the presence of this anion. Although it is likely that an increase in membrane permeability is concerned in the overall mechanism, its precise role is obscure. On the basis of the present results with glucose it is tempting to ascribe the mechanical enhancement observed in the presence of nitrate ion to the increased flux of sugar into the cell, but the fact cannot be discounted that other substances (for example, K^+) which are known to accompany the inward diffusion of glucose might be more immediately related to the observed effect.

By reference to the figure it can be seen that prior treatment with *k*-strophanthoside decreased the response to glucose of ventricles maintained in nitrate-Ringer's. Owing to the fact that the glycogen content of the muscles surviving in the absence of substrate was low[6,7], it can be presumed that the oxidative synthesis of ~ph was severely reduced; hence any manœuvre (such as the addition of *k*-strophanthoside or a similar agent[8]) that tends to increase contractile activity by accelerating ~ph breakdown would be limited in its effectiveness by the amount of oxidizable substrate present. The failure of substrate-depleted ventricles to respond fully to glucose after a 25-min. period of pretreatment with *k*-strophanthoside may be interpreted on the basis that the substrate was entering a muscle which was partially depleted of high-energy phosphate bonds.

We are indebted to Mr. Mungai N'Joroge for help in the preliminary phases of this work, and to Mr. Harry Althouse, of the Sandoz Corporation, for generous supplies of *k*-strophanthoside. These studies were supported, in part, by a grant from the Stanford Medical Research Fund and by a contract between the Office of Naval Research and Stanford University, *ONR–N6–25137*.

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Progesterone Secretion in Ewes

Progesterone secretion during the œstrous cycle of ewes has been measured by means of a chemical assay, with a limit of sensitivity of 0·1 μgm. per ml. of blood[1]. The breeding behaviour of Romney ewes was followed by means of raddled teasers. In fifty-one of these ewes, assays were carried out on blood samples obtained by laparotomy from the ovarian vein draining the active ovary. The results were analysed for an average œstrous cycle of seventeen days, commencing from the day of onset of œstrus.

For the first two days, the amount present was less than 0·1 μgm. per ml. blood. Detectable amounts were present from the third or fourth day, and increased to about the ninth day. The average quantity remained relatively high until the sixteenth day, with a sudden fall on the seventeenth day. In no case was progesterone detected in blood obtained from the jugular vein at the same time.

There was considerable variation between sheep on the same day of the œstrous cycle. For example, on the eleventh day, the average concentration for six ewes was 1·7, and the range was 0·5–3·4 μgm. per ml. blood. The quantity of progesterone in the blood of yearling ewes fell within the range of that of three-year old sheep.

Variations as great as those recorded for different sheep may perhaps occur throughout one day in the individual ewe. The absolute amount of progesterone present at any moment may be less important than the daily total, or even than a minimal quantity. A further variable is probably the responsiveness of the target organs. The balance between progesterone and the œstrogens may be the vital factor.

This work is to be continued, and will be more fully reported elsewhere.

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Participation of the Oxidative Pathway in Yeast Respiration

Recent work has demonstrated the widespread occurrence of enzymes which *in vitro* catalyse reactions in the breakdown of glucose by the so-called hexose monophosphate shunt or oxidative pathway (as distinct from the classical glycolytic route or Embden–Meyerhof–Parnas sequence). Thus the recognition of sedoheptulose phosphate as a labile intermediate and its participation in a cyclic sequence of reactions by which glucose might be completely oxidized[1] has extended the earlier work of Dickens and others and given grounds for supposing that a non-glycolytic breakdown of glucose may occur normally in certain living cells and may, in fact, be a major route of glucose catabolism. The present communication describes results from resting yeast suspensions which are in accord with this supposition.

The method which was used has already been successfully employed by Bloom, Stetten and Stetten to confirm their earlier results from animal tissues which indicated that, in liver slices particularly, the oxidative pathway plays an important part[2]. It is based on the consideration that the mechanism of glucose breakdown will determine the relative rates of release of its constituent carbon atoms into the respired carbon dioxide. Specifically, the carbon dioxide released if the oxidative pathway was operating would be expected to be initially richer in carbon-1 than carbon-6, whereas, if the Embden–Meyerhof–Parnas sequence was the only method of glucose breakdown, carbons-1 and 6 would be expected to appear at equal rates in the respired carbon dioxide.

The yeast (*Saccharomyces cerevisiae*) was grown at 25° C. on a glucose and mineral salts medium. Aliquots of a thin suspension of washed cells in phosphate buffer at *p*H 5·0, on being transferred to Warburg flasks and shaken at 25° C., showed a negligible endogenous oxygen uptake. When glucose was added, oxygen uptake (with respiratory quotient 1·0–1·2) continued until about 40 per cent of it had been oxidized; but most of the experiments were terminated when 10–20 per cent of the supplied glucose had been respired. The experimental period was begun by tipping from the side-arms of duplicate flasks either 10 μM glucose-1-^{14}C or 10 μM glucose-6-^{14}C; the rates of respiration on the two substrates were the same. The carbon dioxide absorbed by potassium hydroxide in the centre well was converted with carbon dioxide carrier into barium carbonate the radioactivity of which was determined with a gas-flow proportional counter[3,4]. The specific activity of the respired carbon dioxide was determined and the yield of carbon-14 dioxide (in mμc.) from each of the glucose samples was evaluated. This was then expressed as a percentage of the supplied activity to arrive at the ratio

$$\frac{\%\text{ radiochemical yield from 1-}^{14}\text{C glucose}}{\%\text{ radiochemical yield from 6-}^{14}\text{C glucose}}$$

This ratio has been designated in the tables as 'C_1/C_6'.

Table 1 shows results from two different yeast samples. It is clear that, whereas the contribution of the C-1 carbon of the glucose to the respired carbon dioxide was relatively large, and its specific activity greater than that of the supplied glucose, that of the C-6 carbon was small. It further appears that, depending on the cultural conditions, the ratio may assume different values. The point we wish to emphasize here, however, is that in none of our experiments have values for the 'C_1/C_6' ratio in the early stages of glucose breakdown been close to unity; values ranging from 2·0 to 5·7 have been recorded, and these must be regarded as minimal since earlier sampling, had it been practicable, would have provided even higher values. These results are taken to indicate that the oxidative pathway was playing a considerable part in the respiration of the cells.

In another type of experiment, carbon dioxide samples were collected at intervals from each of two aliquots of yeast, one respiring on glucose-1-^{14}C and the other on glucose-6-^{14}C. The results are shown in Table 2. During the first period it will be seen that the contribution of C-1 to the carbon dioxide was 2·5 times that of C-6, but that in the later intervals C-6 appeared in increasing amount while the yield of C-1 was declining, so that the ratio fell to 0·38. At the termination of the experiment, when oxygen uptake had virtually ceased, the total per cent yields from C-1 and C-6 were similar, giving an overall ratio of 1·04 and indicating that no permanent assimilation of C-6 over C-1 had occurred. The changing ratio is in accordance with the suggestion that, at least for some of the glucose molecules respired, carbon-1 is split off at an early stage, as would be expected if they were taking the oxidative pathway, and the fact that C-6 appears in larger quantities later would indicate that the reactions leading to its conversion to carbon dioxide succeed those for C-1 release.

Table 1. Recovery of Carbon-14 in the Respired Carbon Dioxide from Yeast Cells Supplied with C-1 or C-6 Labelled Glucose

Yeast	Glucose added	Specific activity of glucose (mμc./mgm.C)	mμc. added	Specific activity of CO_2 (mμc./mgm.C)	mμc. recovered	Recovered (per cent)	'C_1/C_6'
12-hr. cells 'aerated' during growth	10 μM 1-^{14}C 10 μM 6-^{14}C	5·40 4·71	4·02 3·40	5·92 2·50	1·24 0·52	31·0 15·5	2·0
18-hr. cells 'not aerated'	10 μM 1-^{14}C 10 μM 6-^{14}C	18·10 4·71	13·40 3·40	27·10 1·42	2·90 0·15	22·6 4·3	5·2

Table 2. VARIATIONS IN THE RATIO 'C_1/C_6' DURING SUCCESSIVE TIME INTERVALS

	Period I (3 hr.)	Period II (3 hr.)	Period III (5 hr.)	Total
Per cent radiochemical yield from glucose-1-^{14}C	17·2	13·9	2·2	33·3
Per cent radiochemical yield from glucose-6-^{14}C	6·8	19·4	5·9	32·1
'C_1/C_6'	2·53	0·72	0·38	1·04

The above methods have been successfully applied in experiments with various higher plant tissues, and here also the results give some basis for discounting the Embden–Meyerhof–Parnas pathway as the sole mechanism of glucose breakdown. A complete report of this work will be published elsewhere.

This research was carried out at the Brookhaven National Laboratory under the auspices of the United States Atomic Energy Commission. We are indebted to Dr. F. G. Sherman, of Brown University, for the yeast culture, and to Dr. B. L. Horecker, of the National Institutes of Health, for stimulating and helpful discussions.

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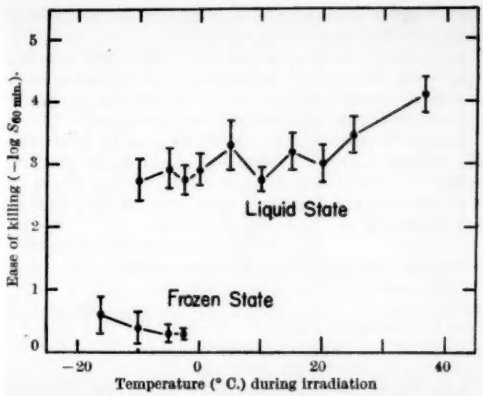
Dependence of X-ray Sensitivity of Bacteriophage on Phase State and Temperature

SEVERAL studies have shown that biological materials are more resistant to ionizing radiations at extremely low temperatures[1–4]. This is usually explained by assuming that diffusion processes involving 'poisons' produced by radiations (OH, HO_2, H_2O_2, etc.) are greatly retarded at low temperatures where there would be negligible free water. The above investigations have not been closely concerned with the region around 0° C. where the liquid–solid phase change would be of importance. The purpose of this report is to describe the influence of temperature (− 16° to 37°) and phase state (liquid or solid) on the radiosensitivity of a bacterial virus.

The test organism was *T*2 bacteriophage, specific for *E. coli*, strain *B*. Suspensions of 10^4 phage/ml. in buffer (3·5 gm. Na_2HPO_4, 1·5 gm. KH_2PO_4, 0·1 gm. $MgSO_4$, 1,000 ml. water) were irradiated in thin glass vials kept in a constant-temperature bath and were diluted afterwards for plating; control and irradiated phage were assayed by standard methods[5]. 250-kV. X-rays at an exposure-rate of 425 r./min. were used for all irradiations. Surviving fractions were computed from controls subjected to the same temperature treatment as irradiated samples. Suspensions kept in the frozen state at the lowest temperatures (− 16° and − 10°) showed about 50 per cent viability to temperature treatment alone; all other temperatures were not harmful as measured by titre. Phage suspensions as described above normally freeze at − 0·5° C.; however, it is possible to supercool these to as low as − 10° C. without great difficulty. Thus it is possible to compare radiosensitivities of test organisms that are suspended at the same temperature during irradiation in a liquid medium (supercooled) and in a solid medium (frozen).



Influence of temperature and phase state on X-ray sensitivity of *T*2 bacteriophage

*T*2 irradiated in liquid buffer displayed survival curves similar to those described by Watson[6], the general shape (concave downward) being fairly independent of the temperature during irradiation. At higher temperatures (above 20°) the radiosensitivity is somewhat increased as previously reported by Alper[7] for *S*13 bacteriophage. However, phages irradiated in frozen buffer were much more resistant to X-irradiation and the survival curves themselves were exponential. The radiosensitivity (negative logarithm of the surviving fraction of phage after sixty minutes irradiation) as a function of temperature and phase state is shown in the accompanying figure.

Different phage samples irradiated at − 10° in (1) solid buffer, (2) liquid broth (5 per cent 'Difco' nutrient broth), and (3) frozen broth, were all equally resistant to X-rays. It has been suggested that the decreased radiosensitivity in liquid broth is due to the elimination of indirect effects by certain 'protective chemicals' of the broth. Since the magnitudes of the protection afforded by liquid broth, solid buffer, and solid broth are the same, it is probable that all three methods eliminate indirect effects. Broth presumably acts by competing for radiation poisons; the solid phase probably protects by hindering the diffusion of these poisons through the supporting medium to the phage particles. It is interesting to note that Bonét-Maury has observed a discontinuity in the amount of hydrogen peroxide production by X-rays at the phase change point, approximately twice as much hydrogen peroxide being produced in the liquid phase as in the solid phase[8]. This, however, is not to be interpreted as meaning that hydrogen peroxide is necessarily the effective poison in the present study.

The residual radiosensitivity observed even when various protective agents are used is probably due to direct inactivation[6,9]. Adams and Pollard[9] found no significant difference between radiosensitivity for *T*1 bacteriophage in broth and in the dried state. They consider that all inactivation in the dried state

is due to direct effects and hence conclude that indirect effects in broth are relatively small.

This phase state phenomenon with supercooled suspensions offers a new parameter that is being used in connexion with other modifying agents to study the mechanism of cell damage by radiations.

This investigation was aided by grants from the U.S. Atomic Energy Commission and from the Dr. Wallace C. and Clara A. Abbott Memorial Fund of the University of Chicago, and was carried out in the laboratory of Prof. R. E. Zirkle.

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A Technique for combining the Staining of Fixed Nuclear Material with the Subsequent Separation of Plant Tissue into Individual Cells

Following an earlier investigation[1], a further study has been made of the mode of action of *iso*-propyl-phenylcarbamate. In order that the observed inhibitory effects on the elongation of *Zea mays* roots could be interpreted in terms of cell division and cell extension, it was necessary to evolve a technique which coupled staining of the nuclear material with the separation of root tips into the individual component cells. The method, developed by Brown[2] for *Pisum sativum*, of gently bombarding carmine-stained root tips with glass beads, failed with maize roots to give adequate cell separation unless the period of bombardment was greatly prolonged, and then too many of the cells were damaged; also the differential staining of the nucleus and cytoplasm was not good enough to allow of the detection of the earliest stages of prophase. The alternative of using a pectinase[3] was then investigated, and eventually the following procedure for the separation of previously stained tissue was found to give excellent results if 'Pectinase' (Nutritional Biochemicals Company, Ohio) was employed.

The roots were first fixed in a mixture of 3 parts absolute alcohol and 1 part glacial acetic acid and stained by the Feulgen technique[4]. After washing in distilled water, the excised root tips were placed in a small volume (for example, 0·5 ml. for ten root tips 1 mm. long) of 2 per cent 'Pectinase' made up in distilled water, adjusted to *p*H 6·6 and saturated with toluol to minimize contamination by micro-organisms. The segments were left in the dark in the 'Pectinase' solution for 12 hr., and at the end of this period most of the 'Pectinase' was removed by a pipette and replaced by an equal volume of 3 per cent solution of a commercial pectin product ('Certo'). By repeated sucking and blowing the tips through a pipette with a fine orifice, the required state of division could be achieved; in order to prevent a loss of cells due to their sticking to the inside of the pipette a very slow intake was followed by vigorous ejection. When a drop of such a suspension was examined under high magnification (× 1,500), it was found that the cells were either completely separated or grouped into small masses of 2, 4, 8, 16 or, very rarely, 32 cells. There was no sign of damage to the individual cells, and all mitotic stages including early prophase were easily recognizable.

Since 'Pectinase' has also been found effective for the separation of fixed cells in both mature root tissue of maize and the meristems of *Vicia faba*, it is likely that this technique of combined staining and cell separation will be generally applicable.

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Histological Demonstration of Alkaline Phosphatase and Non-specific Esterase by Azo-dye Methods

Histochemical methods[1,2] already described are capable of greater sensitivity with reduced artefact formation when employed in a manner similar to that recently reported for the demonstration of acid phosphatase[3]. Increased sensitivity results from enhanced enzyme activity at an incubation temperature of 37° C., demonstration of weak foci of activity in tissues being greatly facilitated. Artefacts resulting from diffusion of enzymically liberated alpha-naphthol is avoided by increasing the speed of azo-coupling and by restriction where necessary of the rate of substrate hydrolysis. Hydrolysis is retarded preferably by reduction of the substrate concentration; this has the advantage over refrigeration of the incubation medium that fast azo-coupling is not prejudiced. For both the usual substrates, sodium alpha-naphthyl phosphate and alpha-naphthyl acetate, the most useful concentrations are 0·01–0·1 mgm./ml.

Accelerated azo-coupling results from incubation at 37° C. and from a high concentration of diazonium salt. Tetrazotized dianisidine (fast blue *B*), one of the most satisfactory compounds available, is best used at a concentration of 0·2–0·4 mgm./ml.; the high incubation temperature does not greatly increase its rate of breakdown or the concomitant tissue background staining. For tissues showing low residual enzyme activity the concentration of diazonium salt should be reduced to avoid excessive enzyme inhibition; otherwise, in the interests of fast azo-coupling the highest tolerated concentration is desirable.

Evidence of accelerated azo-coupling due to the catalytic effect of the quinoline derivative 'Percain' (2-butoxy-N-(2-diethylaminoethyl) cinchoninamide hydrochloride) is afforded by absence of the off-black shades of dye previously shown to be formed at a slow rate of coupling[3]. A further effect of 'Percain', present in the substrate medium at up to 0·4 per cent concentration, is considerably minimized tissue

background staining, apparently due to slowing of the rate of decomposition of the diazonium compound. The low solubility of 'Percain' in alkaline media limits its usefulness in the method for alkaline phosphatase unless a low non-optimal *p*H can be employed; in the method for non-specific esterase (*p*H 7·5) its effects are particularly marked and in neither instance does it inhibit enzymic activity unduly.

This report is based on studies made while in receipt of a grant from the Auckland, N.Z., Division of the British Empire Cancer Campaign Society.

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[1] Gomori, G., *J. Lab. Clin. Med.*, **37**, 526 (1951).
[2] Gomori, G., *L. Lab. Clin. Med.*, **35**, 802 (1950).
[3] Burton, J. F., *J. Histochem. and Cytochem.* (in the press).

Spiral Development of Mycelium in *Aspergillus niger* Colonies

During a recent study of a large number of strains of *Aspergillus niger* we observed a morphological feature not hitherto recorded, so far as we know, for the *A. niger* group. The mycelium growing from a point-inoculation of one strain on a modified Czapek solution agar (normal Czapek solution salts, but 30 per cent sucrose instead of 3 per cent) showed a left-handed twist, or spiral development, when viewed from above in the ordinary way. The word 'spiral' is used loosely, for a form which indeed suggests the picture of a spiral nebula. The tracks both of the primary hyphæ and of their lateral branches curved in a counter-clockwise sense as they advanced.

This led us to examine more closely the early development of many other strains, in order to discover whether spiral development is a general feature of *A. niger* and whether right-handed or clockwise spirals also occur. Only a very few cases of pronounced left-handed spirals were found. One such is shown in Fig. 1; the strain is *A. niger* 289, isolated from sunflower seeds; it has an orange-coloured reverse and is a poor citric acid producer. In a few strains the left-handed tendency was just detectable, but the great majority showed no spiral habit at all. One instance of well-marked right-handed spiral development was found. The mould concerned proved to be a strain of *A. japonicus*, a species of the *A. niger* group characterized in part by having only one series of sterigmata.

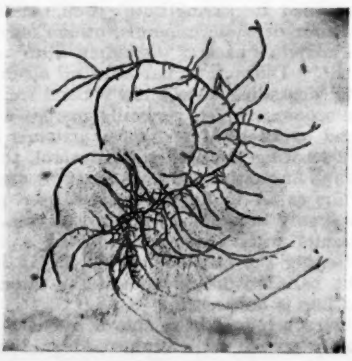

Fig. 1. Left-handed spiral development of colony of *A. niger* 289, 2 days old at 28° C.

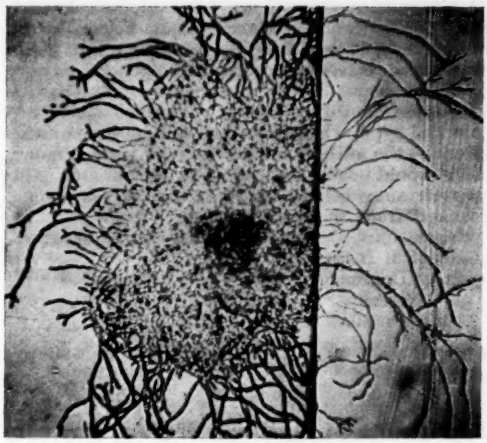

Fig. 2. Young mycelium of *A. japonicus* growing as counter-clockwise spiral on 'Cellophane' overlying agar medium (left), but becoming clockwise after reaching the uncovered medium (right)

Spiral colonies develop whether the cultures are incubated in the dark or in the light, and twist in the same sense relative to the agar surface whether the plates are kept upside-down or the right way up. In case the nature of the agar surface might be a factor determining spiral development, a disk of agar medium, separated from its dish, was inoculated on the surface which had been in contact with the glass. No change in the spiral character of the resulting colony was detected. On the other hand, *A. japonicus*, inoculated at a point near the edge of a square of 'Cellophane' lying on agar medium, showed left-handed spiral development while on the 'Cellophane', but became right-handed again after reaching the edge and spreading on to the agar (Fig. 2). The question as to how the interposition of a 'Cellophane' membrane can bring about this striking reversal remains to be explored.

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Status of *Szechuanopithecus* from the Pleistocene of China

Describing a typical Pleistocene fauna (with *Ailuropoda* and *Tapirus augustus*) from Koloshan, near Chungking, Szechuan, Central China, Young and Liu[1] have recently figured an isolated lower bilophodont tooth, which according to these authors should indicate a new genus of the Cercopithecidae. As fossil Primates are of special interest to everybody concerned with the study of human evolution, I wish to comment on this matter.

The tooth in question is very small—7·2 mm. long and 4·0 mm. wide at its anterior part. It is regarded by the authors as a third molar "with a very much reduced talonid".

A glance at the text-figure, however, reveals that, while the specimen without doubt belongs to a *Cercopithecus*, it cannot be regarded as a last permanent molar, both on account of the general pattern and also because of the divergent roots. There is little doubt that it is a first deciduous molar (d_1) of normal type, which from the lack of comparative material—the authors mainly refer to Elliot's monograph—could not be recognized by the authors. This tooth certainly belongs to *Macacus robustus* Young, described from the same locality.

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Jan. 30.

[1] Young and Liu, *Bull. Geol. Soc. of China*, **30**, p. 52, Fig. 5 (1951).

Experiments on the Cause of Dorsiventrality in Leaves

Sussex[1] has reported that in apices of potato shoots the presumptive area of I_1, the next leaf due to arise, develops into a centric leaf, having the shape of a narrow cone, if isolated from the rest of the stem apex by a vertical cut. Such structures are what we previously called radial leaves[2]. He concludes that the normal dorsiventrality of the leaves is induced by the stem apex. On the other hand, in *Lupinus albus* we found that the presumptive areas of I_1 and of I_2, the next younger leaf again, when similarly isolated, gave rise only to fully dorsiventral leaves with leaflets[2]. We have therefore now isolated by vertical cuts in several potato apices the presumptive area of I_1, or of I_2; but these areas gave rise only to dorsiventral leaves, except in one apex which was seen to be suffering from loss of turgor some hours after the operation. In this apex the isolated I_1 area gave rise to a radial leaf. In a further series of operations on potato apices we made the isolating cuts deep and inserted thin pieces of mica, to keep them open and to prevent substances from diffusing across them. The pieces of mica were left in position for some days, by which time the isolated leaf could usually be seen to have arisen. After about a fortnight the apices were pickled and sectioned, and the cuts were found to be still open. Even in these apices all the isolated presumptive areas which developed further, eight I_1 and two I_2 areas, gave rise to dorsiventral leaves, though one of the leaves, an I_1, was partly tubular. Many of these leaves had indeed looked conical at first when seen in the solid, but when examined in sections later they were seen to be fully dorsiventral, though their blades were often curved inwards towards the stem. These results are quite different from those reported by Sussex, and do not indicate that in potatoes the dorsiventrality of the leaves is induced by the stem apex.

However, in *Epilobium hirsutum*, which forms radial leaves very readily, we have obtained results similar to those reported by Sussex for potato shoots; for the isolated I_1 areas developed only into radial leaves. Yet it is very doubtful whether this indicates that dorsiventrality is induced by the stem apex even in *Epilobium hirsutum*. For in this species, though not in others, we have also obtained radial leaves from the central part of the presumptive area of I_1 and from the central part of P_1, the youngest actual leaf, when these regions were not isolated from the stem apex, but were confined at their sides between two vertical cuts which left them continuous with the stem apex towards the centre. In these experiments the stem apex continued to grow and to form leaves, though its growth was sometimes weakened.

At present, therefore, it seems probable that radial leaves can develop in *Epilobium* from some small part of the apical cone of the stem or from the central part of the youngest actual leaf, when such a part, from causes still not clear, grows up from a base which is not large enough to give rise to a dorsiventral leaf. Even a regenerated apex in *Epilobium* may be converted into a typical radial leaf of limited growth if it is extremely small. Also in our potato apices a few small radial leaves developed from small unoccupied areas of tissue that were left over somewhere between the isolated I_1 leaves and the stem. An effect of reduced size of the isolated areas may perhaps account for the radial leaves reported in potatoes by Sussex, though his isolated pieces do not seem from his drawings and description to have been smaller than most of ours. They do seem, however, to have been too close to P_1 for the correct angular position, which may have made a difference. It needs to be further considered whether in *Epilobium hirsutum* reduced size or perhaps weakened growth of the isolated I_1 areas accounts for the radial leaves which developed from them. We hope to publish a fuller account and discussion of our experiments elsewhere.

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Mary Snow

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Nov. 3.

[1] Sussex, I. M., *Nature*, **170**, 755 (1952).
[2] Snow, M., and Snow, R., *Phil. Trans. Roy. Soc.*, B, **221**, 1 (1931) **225**, 63 (1935).

Degrading Illite and Potash Fixation

Soil clays from Ireland have been examined by X-ray diffraction, and for these soils and some others a relation between potash fixation and clay mineralogy has been established. The clay minerals detected were illite (as defined by Brown[1]), vermiculite, chlorite, kaolin and a material which will be provisionally called 'degrading illite'. Some of the soils contained four of these minerals, others only three.

All the minerals except 'degrading illite' are well established[2]. Diffraction patterns of air-dry clay containing 'degrading illite' show a band from 10 A. to higher spacings which generally merges with the background at 12–13 A. and never extends beyond 14 A. On treating the clay with glycerol, the band disappears giving either (*a*) lines at 10 A. and 14 A. or (*b*) a line at 14 A. It has not yet been possible to decide finally between (*a*) and (*b*) as the mineral always occurs with illite, which gives a line at 10 A. Heating the clay to 350° C. for 12 hr. also causes the band to disappear and the intensity of the 10-A. line is enhanced.

The soils which had been shown by field experiments to fix potash all contained 'degrading illite' while the others did not. None of the other clay minerals showed this simple relationship. It is there-

fore suggested that either 'degrading illite' fixes potash or is related to the actual cause of fixation.

A more detailed account will appear shortly.

I wish to thank Mr. Pierce Ryan, Soil Laboratory, Johnstown Castle, Wexford, for the samples and information about the soils and field experiments.

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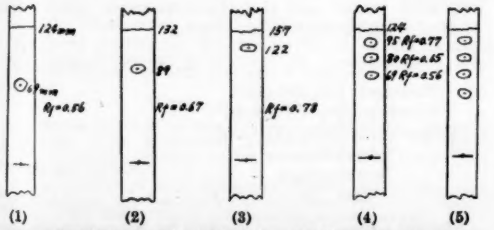
[1] Brown, G., "X-Ray Identification and Crystal Structures of Clay Minerals", Chap. V, Pt. 2 (Mineralogical Society, London, 1951).
[2] Brindley, G. W., *et al.*, "X-Ray Identification and Crystal Structures of Clay Minerals" (Mineralogical Society, London, 1951).

Paper Chromatographic Separation of the Isomeric Pyridinecarboxylic Acids

In the course of study on the synthesis of the hydrazide of isonicotinic acid, starting with '5^0-picoline', I realized the desirability of providing a control method to follow the separation of the isomeric pyridinecarboxylic acids. Paper chromatography using *n*-butanol – methanol, a system suggested by the very different solubilities of the acids in methanol and water, has been shown to be very efficient for the separation of the three isomers. The substances used in this experiment were the α-, β- and γ-pyridinecarboxylic acids, a mixture of all three, and the mixture obtained by oxidation of '5^0-picoline' with potassium permanganate. The solvent used for the development of the substances, as shown in the accompanying figure, was *n*-butanol – methanol containing 35 per cent water by volume at 20° C. The paper used was Tōyō qualitative filter paper No. 3, 2/40 cm., and the usual ascending method was carried out in a thermostat (18°–20° C.).

After the development, the solvent on the paper strips was evaporated at room temperature, and the yellow well-defined spots were revealed on blue background by spraying with bromocresol purple solution (0·2 per cent in *n*-butanol saturated with water). Uni-dimensional chromatograms obtained in these experiments are shown in the figure. It should be stressed that the R_F values of the isomeric pyridinecarboxylic acids have excellent reproducibility under the experimental conditions described above. However, in the case of the developed mixture of the α-, β- and γ-acids, the R_F value of each isomer is slightly lower.

The R_F values of the isomers decrease in the following order: $\beta > \gamma > \alpha$. It may be noted that this is the same sequence as that observed for the dissociation constants[1] of the acids, as determined in aqueous solution.



(1) α-Pyridinecarboxylic acid; (2) γ-pyridinecarboxylic acid; (3) β-pyridinecarboxylic acid; (4) mixture of α-, β-, γ-pyridinecarboxylic acid; (5) oxidative product of '5^0-picoline' with potassium permanganate

I am very grateful to Prof. N. J. Leonard for advice, and I wish to express my gratitude to Mr. M. Wayaku, director of chemical research, Osaka Gas Co., for supplying '5^0-picoline', α-picoline and 2,6-lutidine.

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[1] Ostwald, W., *Z. Phys. Chem.*, **3**, 395 (1889).

Paper Chromatography for the Separation of Neutral 17-Ketosteroids in Urine

Neutral 17-ketosteroids have been isolated from extracts of urine by methods too elaborate for routine application[1,2]. Using chromatography on columns of alumina or silica, quicker methods have been devised[3–7]; but these are still somewhat tedious. Separations have been achieved by chromatography on paper previously impregnated with the stationary phase[7,8]. A technique is here reported for separating the 17-ketosteroids by paper chromatography without any previous impregnation.

The urinary extracts were prepared by the acid hydrolysis of urine followed by extraction with benzene. The benzene extract was washed once with *N* sodium hydroxide, once with distilled water and then dried over anhydrous sodium sulphate. The extract was then shaken with pellets of anhydrous sodium hydroxide[9] to remove most of the pigment remaining, because it was found that much pigment caused streaking of the chromatograms. Finally, the extract was evaporated to dryness and the residue taken up in a small volume of benzene.

The chromatographic tanks and the solvents used were kept at 34·8° ± 0·5° C. in a thermostatically controlled cabinet provided with an efficient fan. For satisfactory results the atmosphere in the tanks must be in equilibrium with the solvent phases, and the precautions described by Bush[10] were observed. The solvent phases were prepared at 34·8° C. A cyclohexane : 20 per cent (v/v) methanol system was used. The Whatman No. 31 paper employed was washed in the mobile phase and dried before use. The extract of urine was applied as spots of approximately 0·5 cm. diameter along a line 14 cm. from one end of a paper strip 40 cm. × 12 cm. For satisfactory results it was found that the amount of 17-ketosteroid in each spot must not exceed 400 μgm. The paper was equilibrated overnight in the tanks and then run for two hours by the descending technique. The strip was dried, sprayed with a freshly prepared mixture of equal volumes of 14 per cent (w/v) alcoholic potassium hydroxide and 2 per cent (w/v) alcoholic meta-dinitrobenzene, and heated in a stream of warm air for ten minutes.

By this technique six ketosteroid fractions can be detected in extracts of normal male urine. Three of the spots have not yet been identified (approximate R_F values: 0·02, 0·4 and 0·8). One spot (R_F approximately 0·07) appears to be 11-hydroxy-aetiocholan-3α-ol-17-one and another may be 11-oxy-aetiocholan-3α-ol-17-one. The most mobile spot (R_F approximately 0·93) is a mixture of aetiocholan-3α-ol-17-one,

androsterone and perhaps 3β-chloro-androst-5-en-17-one. Work is in progress on the further identification of the fractions and the application of the technique to clinical problems.

I would like to acknowledge the financial aid of the Board of Governors of the United Sheffield Hospitals from their Endowment Fund, and to thank Prof. E. J. Wayne and Dr. Arthur Jordan for advice and encouragement.

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[1] Dobriner, K., Lieberman, S., and Rhoads, C. P., *J. Biol. Chem.*, **172**, 241 (1948).
[2] Dobriner, K., Lieberman, S., Rhoads, C. P., Hill, B. R., and Fieser, L. F., *J. Biol. Chem.*, **172**, 263 (1948).
[3] Dingemanse, E., Huis in't Veld, L. G., and de Laat, B. M., *J. Clin. Endocrinol.*, **6**, 535 (1946).
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[5] Pond, M. H., *Lancet*, ii, 906 (1951).
[6] Zygmuntowicz, A. S., Wood, M., Christo, E., and Talbot, N. B., *J. Clin. Endocrinol.*, **11**, 578 (1951).
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[8] Axelrod, L. R., *J. Biol. Chem.*, **205**, 173 (1953).
[9] Drekter, I. S., Heisler, A., Scism, G. R., Stern, S., Pearson, S., and McGavack, J. H., *J. Endocrinol.*, **12**, 55 (1952).
[10] Bush, I. E., *Biochem. J.*, **50**, 370 (1952).

Quantitative Evaluation of Paper Chromatograms by Infra-red Absorption

The amounts of materials adsorbed on paper chromatograms can often be estimated directly from measurements of the optical densities of the spots produced by colour-forming reagents. In some cases, it is possible to avoid the colour-forming reaction by measuring the ultra-violet or visible absorptions of the materials themselves. Bellamy[1] has shown that it is possible to examine directly the infra-red spectra of materials adsorbed on paper chromatograms, and it has now been found possible to make quantitative measurements on paper chromatograms by scanning the paper with infra-red radiation of suitable wave-lengths. This method may prove to be particularly useful for substances which do not absorb in the ultra-violet or visible regions and which do not undergo quantitative colour-forming reactions.

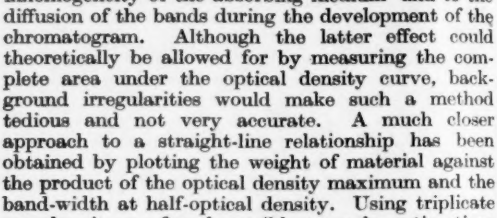
In general, the infra-red method is not as sensitive as the ultra-violet method, since the molar extinction coefficients of infra-red bands are usually several hundred times less than those of ultra-violet absorption bands. Irregularities in the paper are more readily observed when scanning with infra-red radiation, and since all papers appear to transmit radiation more uniformly when cut along one direction, it is necessary first to compare paper strips cut both along and across the machine direction. The need to reduce reflexion by wetting with 'Nujol' limits the most useful range for infra-red scanning to about 2,500–1,500 cm.$^{-1}$. Whatman No. 50 papers appear to be most satisfactory for this work.

Preliminary experiments have been carried out with paper chromatograms of amino-acids which have been developed in 50 per cent aqueous ethanol as solvent. Although other solvent systems would give better separations on the paper, this solvent was selected since it could be removed easily from the paper by warming.

A slightly enlarged image of a Nernst filament was projected on to a paper strip 30 mm. wide. The central portion of the illuminated area, 25 mm. × 3 mm., was re-imaged on to the monochromator entrance slit of a Grubb Parsons *S*3 single-beam infra-red spectrometer, the paper strip being drawn across the filament image at a uniform rate of 1 in. per minute. An instrumental slit-width of 0·5 mm. was used, corresponding to a spectral slit-width of 25 cm.$^{-1}$ at the 1,610 cm.$^{-1}$ amino-acid absorption band.

In order to obtain a higher loading and greater sensitivity, the 5·6-μl. samples of the amino-acid solutions were banded uniformly across the paper strips. After developing the chromatograms for several hours, drying off the solvent and wetting with 'Nujol', the strips were scanned in the apparatus.

It has been found that, in the case of bands which have been developed for approximately the same time interval, a smooth curve related the optical density maximum to the weight of material on the paper. Estimations could be made from this curve with an accuracy of about ± 10 per cent. This non-linear relationship is most probably due to the inhomogeneity of the absorbing medium[2] and to the diffusion of the bands during the development of the chromatogram. Although the latter effect could theoretically be allowed for by measuring the complete area under the optical density curve, background irregularities would make such a method tedious and not very accurate. A much closer approach to a straight-line relationship has been obtained by plotting the weight of material against the product of the optical density maximum and the band-width at half-optical density. Using triplicate samples, it was found possible to make estimations to ± 5 per cent by this method.



Absorption of glycine (*G*) and alanine (*A*) at 1,610 cm.$^{-1}$

The upper line in the accompanying figure shows the recording made from a chromatogram of 560 μgm. glycine and 560 μgm. alanine, after development for 15 hr. The lower line represents the transmission of the same paper strip after the 'Nujol' had been washed off with chloroform, the amino-acids washed out with water and the chromatogram strip again wetted with 'Nujol' after drying.

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[1] Bellamy, L. J., *J. App. Chem.*, **3**, 421 (1953).
[2] Jones, R. N., *J. Amer. Chem. Soc.*, **74**, 2681 (1952).

FORTHCOMING EVENTS

*(Meetings marked with an asterisk * are open to the public)*

Monday, April 5

SOCIETY OF ENGINEERS (in the Apartments of the Geological Society, Burlington House, Piccadilly, London, W.1), at 5.30 p.m.—Dr. A. A. Wells: "Brittle Fracture in Steel Structures, with special reference to Liberty Ships".

MANCHESTER LITERARY AND PHILOSOPHICAL SOCIETY (in the Reynolds Hall, College of Technology, Manchester), at 5.45 p.m.—Prof. Sir Geoffrey Jefferson, F.R.S.: "Thinking and Talking" (President's Address).

ROYAL GEOGRAPHICAL SOCIETY (at 1 Kensington Gore, London, S.W.7), at 8.15 p.m.—Mr. Helge Larsen: "Alaskan Eskimo Past and Present".

Monday, April 5—Wednesday, April 7

INSTITUTION OF CHEMICAL ENGINEERS (at The University, Birmingham)—Symposium on "Gas Absorption".

SOCIETY OF CHEMICAL INDUSTRY, LONDON SECTION (at the Senate House, University of London, Gower Street, London, W.C.1).—Symposium on "Ion Exchange and Its Applications".

Monday, April 5—Thursday, April 8

ERGONOMICS RESEARCH SOCIETY (at Ashmore Hill, Nr. Leamington Spa), Fourth Annual Conference—"The Scientific Study of Human Work in Industry" (Symposium Secretary: Barbara Murrell, Slaters Cottage, Peppard Common, Henley-on-Thames, Oxon.).

Tuesday, April 6

BRITISH OCCUPATIONAL HYGIENE SOCIETY (at the London School of Hygiene and Tropical Medicine, Keppel Street, London, W.C.1), at 11 a.m.—Conference on "Maximum Allowable Concentrations of Harmful Materials in Industrial Atmospheres".

INSTITUTION OF ELECTRICAL ENGINEERS, MEASUREMENTS SECTION (at Savoy Place, London, W.C.2), at 5.30 p.m.—Scientific Papers.

SOCIETY FOR ANALYTICAL CHEMISTRY, PHYSICAL METHODS GROUP (at the Chemical Society, Burlington House, Piccadilly, London, W.1), at 6.30 p.m.—Meeting on "Mass Spectrometry".

ROYAL SOCIETY OF MEDICINE, PATHOLOGY SECTION (at 1 Wimpole Street, London, W.1), at 8 p.m.—Symposium on "Immunological Problems on Tissue Grafting".

Tuesday, April 6—Friday, April 9

INSTITUTE OF PHYSICS (at the University, Nottingham).—Conference on "The Physics of Particle Size Analysis".

Wednesday, April 7

ROYAL PHOTOGRAPHIC SOCIETY, SCIENTIFIC AND TECHNICAL GROUP (at the Imperial College of Science and Technology, Prince Consort Road, London, S.W.7), at 2.30 p.m.—Symposium on "The Applications of Photography to Research at the Imperial College of Science and Technology".

SOCIETY FOR ANALYTICAL CHEMISTRY (at the Wellcome Research Institution, Euston Road, London, N.W.1), at 2.30 p.m.—Symposium on "The Comparison of Chemical and Biological Estimation of Drugs in Quantitative Pharmacology". Chairman: Prof. J. H. Burn, F.R.S.

ROYAL METEOROLOGICAL SOCIETY (at 49 Cromwell Road, London, S.W.7), at 5 p.m.—Dr. G. K. Batchelor: "Heat Convection and Buoyancy Effects in Fluids" (Symons Memorial Lecture).*

INSTITUTION OF MECHANICAL ENGINEERS, INTERNAL COMBUSTION ENGINE GROUP (at 1 Birdcage Walk, Westminster, London, S.W.1), at 6.45 p.m.—Discussion on "The Performance of Compression-Ignition Engines under Abnormal Conditions (including Altitude, Temperature, Humidity, Load, Speed or Speed-Variation, Fuel Supply, etc.).

RADAR ASSOCIATION (in the Anatomy Theatre, University College, Gower Street, London, W.C.1), at 7.30 p.m.—Mr. P. A. L. Harris: "Radar and the Weather".

Wednesday, April 7—Friday, April 9

FARADAY SOCIETY (in the Department of Chemistry, The University, Birmingham)—General Discussion on "The Study of Fast Reactions".

INSTITUTION OF NAVAL ARCHITECTS (on board the Headquarters Ship *Wellington*, Honourable Company of Master Mariners, Victoria Embankment, London, W.C.2), at 10.15 a.m. daily.—Spring Meeting.

Wednesday, April 7—Saturday, April 10

INSTITUTE OF PHYSICS, ELECTRONICS GROUP (in the Cavendish Laboratory, Cambridge).—Conference on "Luminescence" (with particular reference to Solid Inorganic Phosphors).

Thursday, April 8

INSTITUTE OF FUEL (at the Institution of Mechanical Engineers, 1 Birdcage Walk, Westminster, London, S.W.1), at 4.30 p.m.—Annual Corporate Meeting; 5.30 p.m.—Dr. W. Idris Jones: First Presidential Address.

ROYAL SOCIETY OF ARTS, COMMONWEALTH SECTION (at John Adam Street, Adelphi, London, W.C.2), at 5.15 p.m.—Prof. O. G. Sutton, F.R.S.: "The Meteorological Office and the Commonwealth".

SOCIETY OF CHEMICAL INDUSTRY, MICROBIOLOGY GROUP (at the Medical Society of London, 11 Chandos Street, Cavendish Square, London, W.1), at 6 p.m.—Annual General Meeting; Sir Ian Heilbron: "Research at the Brewing Industry Research Foundation".

SOCIETY OF INSTRUMENT TECHNOLOGY (joint meeting with the CONTROL SECTION, at Manson House, 26 Portland Place, London, W.1), at 6.30 p.m.—Discussion on "Rationalisation of Units for Electrically Operated Servos".

SOCIETY OF DYERS AND COLOURISTS (at the Midland Hotel, Manchester 2), at 7.30 p.m.—Mr. N. W. Yelland: "Physics in the Dyeing, Printing and Finishing Industries" (Eleventh Mercer Lecture).*

Thursday, April 8—Saturday, April 10

SOCIETY FOR GENERAL MICROBIOLOGY (at the Institution of Electrical Engineers, Savoy Place, London, W.C.2).—Annual General Meeting.

Thursday, April 8
Scientific Papers.

Friday, April 9—Saturday, April 10
Symposium on "Autotrophic Micro-organisms".

Friday, April 9

BIOCHEMICAL SOCIETY (in the Department of Biochemistry, University New Buildings, Edinburgh 8), at 11 a.m.—Scientific Papers.

ASSOCIATION OF APPLIED BIOLOGISTS (in the Metallurgy Lecture Theatre, Imperial College, Prince Consort Road, London, S.W.7), at 11 a.m.—Annual General Meeting; 2.30 p.m.—Dr. E. C. Bate-Smith: "Objectives in Food Research".

INSTITUTION OF MECHANICAL ENGINEERS (at 1 Birdcage Walk, Westminster, London, S.W.1), at 5.30 p.m.—Paper on "The Control and Observation of Dust at Pneumatic Chisels and Portable Abrasive Wheels". Part 1—Mr. A. T. Holman and Mr. E. B. James: "Dust Control Systems"; Part 2—Mr. W. B. Lawrie: "Dust Observations".

ROYAL SOCIETY OF MEDICINE (at 1 Wimpole Street, London, W.1), at 8.30 p.m.—Dr. M. G. Candau: "The Rôle of W.H.O. in International Health Work".

Friday, April 9—Saturday, April 10

BOTANICAL SOCIETY OF THE BRITISH ISLES (at Church House, Great Smith Street, Westminster, London, S.W.1), at 10.15 a.m. each day.—Conference: "The Species Concept in its Relation to the British Flora".

APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned:

ASSISTANT ANALYST (with a university degree or A.R.I.C., and preferably with experience in the analysis of food and drugs)—The County Medical Officer of Health, East Cliff County Offices, Preston, quoting "Assistant Analyst" (April 10).

ASSISTANT COAL SURVEY OFFICER (with a good honours degree or equivalent in chemistry or fuel technology, and preferably with experience in industry, in laboratory control, and in the critical assembly of scientific data) at the Coal Survey Laboratory, Sheffield—The National Coal Board, Establishments (Personnel), Hobart House, Grosvenor Place, London, S.W.1, quoting TT/754 (April 10).

ENGLISH ELECTRIC COMPANY RESEARCH FELLOW (graduate in engineering or applied science, and some experience in aircraft engineering practice) IN AERONAUTICS, at the University of Glasgow—The Secretary of the University Court, The University, Glasgow (April 10).

PROFESSOR AND HEAD OF THE DEPARTMENT OF AERODYNAMICS—The Principal, The College of Aeronautics, Cranfield, Bletchley, Bucks (April 13).

SENIOR LECTURER IN MECHANICAL ENGINEERING, LECTURERS (2) IN MECHANICAL OR CIVIL ENGINEERING, a LECTURER IN ELECTRONICS, a LECTURER IN ELECTRICAL ENGINEERING, a LECTURER IN PHYSICS, and DEMONSTRATORS IN PHYSICS OR MECHANICAL ENGINEERING OR ELECTRONICS, at the Royal Military College of Science, Shrivenham—The Civil Service Commission, Scientific Branch, 30 Old Burlington Street, London, W.1, quoting S.4307/54 (April 15).

UNIVERSITY PROFESSOR OF PHYSIOLOGY at Patna University, India—The Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.1 (April 17).

ASSISTANT LECTURERS (2) IN PSYCHOLOGY—The Registrar, The University, Manchester (April 21).

TURNER AND NEWALL RESEARCH FELLOWSHIP IN ENGINEERING, INORGANIC CHEMISTRY OR PHYSICS or other allied science—The Registrar, The University, Leeds 2 (April 21).

ASSISTANT LECTURER (with an honours degree in mathematics) IN MATHEMATICS—The Secretary, Bedford College, Regent's Park, London, N.W.1 (April 23).

ANALYST, Assistant Experimental Officer grade or Experimental Officer grade, in the Insecticides and Fungicides Section at Long Ashton Research Station, for work concerned mainly with the development and application of methods for the determination of insecticide and fungicide deposits on plants—The Secretary, Research Station, Long Ashton, Bristol (April 24).

CHAIR OF PHYSIOLOGY in the University College, Ibadan—The Secretary, Senate Committee for Higher Education in the Colonies, Senate House, London, W.C.1 (April 24).

LECTURER (with a good honours degree in biochemistry, agricultural chemistry or chemistry, and with postgraduate research experience in biochemistry) IN AGRICULTURAL BIOCHEMISTRY, a LECTURER IN SURVEYING AND FOREST ENGINEERING in the Department of Forestry, and an ASSISTANT LECTURER (with special qualifications in applied mathematics) IN MATHEMATICS—The Secretary and Registrar, University College of North Wales, Bangor (April 26).

LECTURER (with special qualifications in mechanical engineering) IN ENGINEERING—The Registrar, The University, Manchester 13 (April 26).

LECTURERS (3) or ASSISTANTS (3) IN GEOLOGY—The Secretary of University Court, The University, Glasgow (April 30).

CHAIR OF CHEMICAL PATHOLOGY tenable at St. Mary's Hospital Medical School—The Academic Registrar, University of London, Senate House, London, W.C.1 (May 3).

LECTURER (Grade II) or ASSISTANT LECTURER (Grade III) IN THE DEPARTMENT OF THEORETICAL MECHANICS—The Registrar, The University, Bristol (May 7).

LECTURER IN MINING—The Registrar, University College of South Wales and Monmouthshire, Cathays Park, Cardiff (May 8).

READER IN EXPERIMENTAL PHYSICS at Queen Mary College—The Academic Registrar, University of London, Senate House, London, W.C.1 (May 10).

RESEARCH ASSISTANT IN THE DEPARTMENT OF MINING—The Registrar, University College of South Wales and Monmouthshire, Cathays Park, Cardiff (May 22).

ANGLO-IRANIAN OIL CO. STUDENT (with good degree, and preferably research experience) IN THE CHEMISTRY DEPARTMENT, for study of kinetics of gaseous reactions—The Registrar, Imperial College of Science and Technology, London, S.W.7 (May 24).

CHAIR OF PURE MATHEMATICS—The Registrar, The University, Birmingham (May 31).

LECTURER (with a university degree, preferably in forestry, and practical experience of forestry in Great Britain or abroad) IN FORESTRY—The Secretary, The University, Edinburgh (June 15).

ASSISTANT LECTURER IN GEOGRAPHY—The Secretary, University College, Exeter.

CHEMIST (with an honours degree in chemistry, metallurgy or chemical engineering, or equivalent qualifications) at the Ministry of Supply, Woolwich, to take charge of electro-deposition unit on pilot plant scale—The Ministry of Labour and National Service, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting F.170/54A.

CHEMIST or BIOCHEMIST (preferably with a knowledge of the chemistry of either fats, proteins or starch, and/or modern laboratory techniques) for fundamental research work—The Director of Research, Baking Industries Research Station, Chorleywood, Herts.

HEAD (with a degree in science or engineering, and some research experience, and preferably with a knowledge of the iron and steel industry) OF THE BRITISH IRON AND STEEL RESEARCH ASSOCIATION'S NORTH EAST COAST LABORATORIES at Normanby, near Middlesborough, to lead a team of some twenty scientists and technicians operating on problems in connexion with iron-making and iron-making processes—The Personnel Officer, B.I.S.R.A., 11 Park Lane, London, W.1, quoting "Normanby".

LECTURER (with a university degree in agriculture, and preferably with a knowledge of tropical agriculture, and some teaching experience) IN AGRICULTURE, at the College of Agriculture, Mauritius—The Director of Recruitment, Colonial Office, Great Smith Street, London, S.W.1, quoting CDE.63/52/06.

PHYSICISTS and ENGINEERS (with at least H.S.C. (science) or equivalent) IN THE GUIDED WEAPONS DEPARTMENT, Royal Aircraft Establishment, Farnborough, Hants, to assist in development, testing and maintenance of kinetheodolites, special oscillograph cameras, and other associated equipment in target aircraft—The Ministry of Labour and National Service, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting A.65/54A.

RESEARCH STATISTICIANS (with a good honours degree in mathematics (including statistics), and preferably with research experience in statistics) in the Department of Statistics, for work concerned with the development of statistical theory and its application to agricultural and general biological problems—The Secretary, Rothamsted Experimental Station, Harpenden, Herts.

RESEARCH STUDENT (with a good physics degree and some experience of electronics) to work on a special project which will provide opportunity for study for a higher degree—The Professor of Electronics, The University, Southampton.

SENIOR SCIENTIFIC OFFICER (with a first- or second-class honours degree in chemistry, or an equivalent qualification, and at least three years postgraduate research experience, and a knowledge of plastics, paints, adhesives, rubbers and/or surface chemistry) to assist in the control of a chemical development section covering miscellaneous research problems in the organic chemistry field—The Administrative Officer, Recruitment, Atomic Weapons Research Establishment, Aldermaston, Berks, quoting 49/W.G.E./2.

REPORTS and other PUBLICATIONS

(not included in the monthly Books Supplement)

Great Britain and Ireland

Council for the Promotion of Field Studies. Annual Report 1952–53. Pp. 82+8 plates. (London: Council for the Promotion of Field Studies. 1954.) [22

Aluminium Development Association. Research Report No. 22: The Determination of Torsion Constants for Bulbs and Fillets by means of an Electrical Potential Analyser. By P. J. Palmer. Pp. 24. (London: Aluminium Development Association, 1953.) 7*s*. 6*d*. [22

Society for Freedom in Science. Occasional Pamphlet No. 14: Pure and Applied Science and their Appropriate Forms of Organization. By Michael Polanyi. Pp. 13. 1*s*. 3*d*. Occasional Pamphlet No. 15: Freedom and Authority in Scientific Publication. By John R. Baker. Pp. 14. 1*s*. 3*d*. (Oxford: Society for Freedom in Science, 1953.) [22

Liverpool Observatory and Tidal Institute. Annual Report, 1953. Pp. 15. (Liverpool: Liverpool Observatory and Tidal Institute, 1954.) [22

Building Research Station Digest No. 62 (January 1954): Review of Enquiries, 1953. Pp. 4. (London: H.M. Stationery Office, 1954.) 3*d*. net. [22

Annual Report of the National Oceanographic Council, 1 April 1952—31 March 1953. Pp. v+34+3 plates. (Cambridge: At the University Press, 1954.) 5*s*. net. [22

British Commonwealth Scientific Office: North America. The BCSO Review of Science in U.S.A. for the year ending June 1953. (United Kingdom Scientific Mission, Canadian Scientific Liaison Office, Australian Scientific Liaison Office, New Zealand Scientific Liaison Office, South African Scientific Liaison Office.) Pp. iv+44. (London: H.M. Stationery Office, 1954.) 2*s*. net. [22

The Scottish Genealogist. (Quarterly journal of the Scottish Genealogy Society.) No. 1 (January 1954.) Pp. 24. (Edinburgh: Scottish Genealogy Society, 1954.) 2*s*. 6*d*. [22

The Year Book of the Royal Society of London, 1954. (No. 58.) Pp. 311. (London: The Royal Society of London, 1954.) 15*s*. [48

Farming to Feed Britain: a Policy for Farm Workers, Farmers and Consumers. Pp. 24. (London: The Communist Party, 1954.) 6*d*. [42

M. and B. Laboratory Bulletin. Vol. 1, No. 1 (January 1954.) Pp. 12. (Dagenham: May and Baker, Ltd., 1954.) [42

The Registrar General's Statistical Review of England and Wales for the Five Years 1946–1950, Text, Civil. Pp. vii+244. (London: H.M. Stationery Office, 1954.) 6*s*. 6*d*. net. [52

Communications of the Dublin Institute for Advanced Studies. Series A, No. 11: On Relativistically Rigid Surfaces of Revolution. By J. R. Pounder. Pp. vi+53. (Dublin: Dublin Institute for Advanced Studies, 1954.) 3*s*. [52

Other Countries

Lady Tata Memorial Trust (International Section). Report on the Research Work on Leukaemia and Allied Diseases, assisted on the recommendation of the (European) Scientific Advisory Committee, from the 1st October, 1947 to the 30th September, 1952. Pp. 34. (Bombay: Lady Tata Memorial Trust, 1953.) [271

Smithsonian Institution: United States National Museum. Bulletin 203: Life Histories of North American Wood Warblers. Order Passeriformes. By Arthur Cleveland Bent. Pp. xi+734+83 plates. (Washington, D.C.: Government Printing Office, 1953.) 4.50 dollars (paper). [22

Annual Report of the Board of Regents of the Smithsonian Institution, showing the Operations, Expenditures, and Condition of the Institution for the Year Ended June 30, 1952. Pp. ix+461+43 plates. (Washington, D.C.: Government Printing Office, 1953.) 2.75 dollars. [22

Fortschritte der Physik. Band 1, Heft 5, 1953: Schwingungsspektren fester Körper. Von G. Leibfried und W. Brenig. Pp. 187–218. Untersuchung der Ultrarotstrahlung des Nachthimmels. Von W. I. Krassowski. Pp. 219–238. (Berlin: Akademie Verlag, 1953.) [22

Aportacion de la Escuela Espanola a la Tecnica Endobronquial: Analisis Cronologico y Doctrinal. (Conferencia pronunciada en la Real Academie Nacional de Medicine.) Por el Dr. D. A. Garcia-Vicente. Pp. 43. (Madrid: Dr. S. Garcia Vicente, Paseo de la Castellana, 78, 1953.) [22

International Federation of Culture Collection of Micro-organisms. Annual Report, 1952. Pp. 24. (New York: International Federation of Culture Collections of Micro-Organisms, 1953.) [22

National Institute of Genetics (Japan). Annual Report, 1952. (No. 3.) Pp. iii+69. (Misima, Sizuoka-Ken: National Institute of Genetics, 1953.) [22

The Third Annual Report of the National Science Foundation. Year ending June 30, 1953. Pp. vii+110. (Washington, D.C.: Government Printing Office, 1953.) 40 cents. [22

U.S. Department of Agriculture. Farmers' Bulletin No. 1624: The Mexican Bean Beetle in the East and Its Control. (Revised edition.) Pp. 16. (Washington, D.C.: Government Printing Office, 1953.) 10 cents. [22

Bulletin of the Museum of Comparative Zoology at Harvard College, Vol. 111, No. 1: Revisionary Notes on the Ant Genus Myrmecia of Australia. By William L. Brown, Jr. Pp. 36. Vol. 111, No. 2: Ticks (Ixodoidea) of the Malagasy Faunal Region (Excepting the Seychelles): Their Origins and Host-relationships; with descriptions of five new *Haemaphysalis* species. By Harry Hoogstraal. Pp. 37–114. (Cambridge, Mass.: Museum of Comparative Zoology at Harvard College, 1953.) [22

Sudan Government. Ministry of Agriculture-Forests Department. Report for the period July 1951 to June 1952. Pp. iv+70. (Khartoum: Ministry of Agriculture, Forests Department, 1953.) [22

Forest Department, Kingston, Jamaica, B.W.I. Annual Report for the year ended 31st March, 1953. Pp. 12. (Kingston, Jamaica: Forest Department, 1953.) [22

Kungl. Svenska Vetenskapsakademiens Handlingar. Fjärde Serien, Band 4, No. 1: Die Diatomeen von Schweden und Finnland Teil 2: Arraphideae, Brachyraphideae. Von Astrid Cleve-Euler. Pp. 158+35 plates. 40 kronor. Fjärde Serien, Band 4, No. 4: Ein Nordisches Kerngebiet im Mittleren West-Dalarna. Von B. Lundman. Pp. 7. 2 kronor. (Stockholm: Almqvist and Wiksells Boktryckeri-AB.; London: H. K. Lewis and Co., Ltd., 1953.) [22

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MACMILLAN & CO., LTD.,
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Telephone Number: Whitehall 8831. Telegrams: Phusis Lesquare London

Annual subscription £6, payable in advance, postage paid to any part of the world

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